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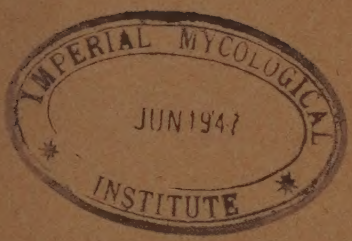
NOUVELLE SÉRIE

1944



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MATHEMATICS

GENERAL THEOREMS ON THE ESTIMATIONS OF TRIGONOMETRIC SUMS

By I. M. VINOGRADOFF, Member of the Academy

Revising for a new book my method of 1934 I obtained better formulations for many of the theorems established by this method. Part of these formulations I should like to publish at once (detailed proofs will be given in the book), since their use in the theory of numbers extends over a variety of investigations based on my method.

Theorem 1. *Let* m, Q, P *be integers*, $m > 0$, $P > 0$,

$$F(x) = a_{n+1} x^{n+1} + \ldots + a_1 x_1, \quad n \geqslant 11$$

$a_{n+1}, \ldots, a_1$, *real numbers*; a_s, *one of the numbers* $a_{n+1}, \ldots, a_2$

$$a_s = \frac{a}{q} + \frac{\theta}{q^2}, \quad (a, q) = 1, \quad |\theta| \leqslant 1, \quad S = \sum_{x=Q+1}^{Q+P} e^{2\pi i m F(x)}$$

Then, adopting the notation $A \ll B$ *for* $|A| \leqslant C|B|$, *where* C *is an absolute constant, we have*

1. $S \ll P^{1-\rho_1} m^{2\rho_1}$, $\rho_1 = \dfrac{\tau}{3\, n^2 \log \dfrac{5n}{\sqrt{\tau}}}$ *if* $1 < q \leqslant P$, $q = P^{\tau}$.

2. $S \ll P^{1-\rho_2}\, m^{2\rho_2}$, $\rho_2 = \dfrac{1}{3n^2 \log 5n}$ *if* $P \leqslant q < P^s$.

3. $S \ll P^{1-\rho_3}\, m^{2\rho_3}$, $\rho_3 = \dfrac{\tau}{3n^2 \log \dfrac{5n}{\sqrt{\tau}}}$ *if* $P^s \leqslant q \leqslant P^{s+1}$, $q = P^{s+1-\tau}$.

Example. Let $a_2 = \sqrt{2}$ in the expression for $F(x)$. Then $|S| \ll P^{1-\rho_2}\, m^{2\rho_2}$.

Remark. In case n is constant, the number ρ_3 may be replaced by $\dfrac{\tau}{9n^2 \log 9n^2}$. For an increasing n the possibility of this replacement has not yet been explored.

Theorem 1 gives a unified method for the estimation of sums S in dependence on rational approximation to any of the coefficients $a_{n+1}, \ldots, a_2$ (and not only to a_{n+1}). For the completeness of the theorem only the case $s = 1$ is wanting. But one may bring this case under the scope of a most general, though less precise theorem. Thus, Theorem 1, as regards its range of applicability, is very nearly complete.

Not so with regard to accuracy of estimations. In this respect Theorem 1 is by no means final. In fact, let $a_{n+1}, \ldots, a_{s+1}, a_{s-1}, \ldots, a_1$ be given, and the number a_s vary in the interval $0 \leqslant a_s \leqslant 1$. If $0.5 < \delta < 1$, then we may

find in the interval $0 \leqslant a_s \leqslant 1$ a finite number of non-overlapping intervals, the sum of whose lengths is $\geqslant 1 - P^{1-2\delta}$ such that $S \ll P^{\delta}$, provided that a_s lies in one of them.

Theorem 2. *Let n be an integer, $n \geqslant 11$, Q and P integers, $P > 0$, $f(x)$ a real function in the interval $Q < x \leqslant Q+P$ satisfying the conditions*

$$\frac{1}{A} \leqslant \left|\frac{f^{(n)}(x)}{n!}\right| \leqslant \frac{l}{A}, \qquad \left|\frac{f^{(n+1)}(x)}{(n+1)!}\right| \leqslant \frac{f\sqrt{l}}{AP}$$

where $A = hP^{\mu}$, $h \geqslant 1$, $1 \leqslant \mu \leqslant 3$.

Let, further, P_0 be an integer, $1 \leqslant P_0 \leqslant P$,

$$S = \sum_{x=Q+1}^{Q+P_0} \Phi(x)\, e^{2\pi i f(x)}$$

and suppose that $\Phi(x)$ varies monotonously only in the interval $Q \leqslant x \leqslant Q+P$, without changing sign and never exceeding M numerically. Then

$$S \ll M\,(l^2 fh)^{\rho} P^{1-\rho}, \quad \rho = \frac{1}{3n^2 \log 5\mu n}.$$

Example. Let $s = \sigma + it$, $\sigma > 0$, $t > 0$, P and P_0 integers, $t^{\frac{1}{n-1}} \leqslant P \leqslant t^{\frac{1}{n-2}}$,

$$0 < P_0 \leqslant P, \quad S = \sum_{x=1}^{P_0} \frac{1}{(P+x)^s}.$$

Here we have

$$S = \sum_{x=1}^{P_0} \Phi(x)\, e^{2\pi i f(x)}, \quad \Phi(x) = \frac{1}{(P+x)^{\sigma}},$$

$$f(x) = \frac{t \log (P+x)}{2\pi}, \quad \left|\frac{f^{n}(x)}{n!}\right| = \frac{t}{2\pi n\,(P+x)^{n}},$$

$$\left|\frac{f^{(n+1)}(x)}{(n+1)!}\right| = \frac{t}{2\pi (n+1)(P+x)^{n+1}}$$

The conditions of Theorem 2 are satisfied, if

$$A = \frac{2\pi n 2^n P^n}{t}, \quad l = 2^n, \quad f = 2 \cdot 2^{0.5n}, \quad h = 2\pi n 2^n, \quad \mu = 2, \quad M = \frac{1}{P^{\sigma}}$$

and we have (the notation $A \ll B$ being used in the sense indicated above)

$$S \ll \frac{1}{P^{\sigma}} (n 2^{3.5n})^{\rho} P^{1-\rho}, \quad \rho = \frac{1}{3n^2 \log 10n}$$

or, finally,

$$S \ll P^{1-\sigma-\rho}$$

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MATHÉMATIQUES

SUR LA COMPACITÉ DES SYSTÈMES DE FONCTIONS PRESQUE-PÉRIODIQUES GÉNÉRALISÉES DE A. BESICOVITCH

Par A. S. KOVANKO

(Présenté par A. N. Kolmogoroff, de l'Académie, le 28.X.1943)

Le but de la présente Note est de trouver les conditions pour qu'un système de fonctions presque-périodiques généralisées de Besicovitch soit compact. Nous examinons l'espace de fonctions mesurables et nous faisons usage de nos résultats (1) concernant la même question pour fonctions $f(x)$ dont $|f|^\omega$ est sommable.

Introduisons quelques notations.

I. Soit $E(a,b)$ la partie d'un ensemble mesurable E situé sur l'intervalle (a,b). $|E(a,b)|$ désigne sa mesure.

Posons

$$\delta_B E = \overline{\lim_{T\to\infty}} \frac{|E(-T,+T)|}{2T}.$$

II. Soit $f(x)$ et $\varphi(x)$ deux fonctions mesurables sur $(-\infty,+\infty)$. Soit $E_A(\subset E)$ l'ensemble de points, où $|f(x)-\varphi(x)|\geqslant A$. Introduisons la distance entre $f(x)$ et $\varphi(x)$ dans l'espace des fonctions mesurables — $\mathfrak{D}_B^E(f,\varphi)$

$$\mathfrak{D}_B^E(f,\varphi) = \inf_{0\leqslant A\leqslant+\infty} [A+\delta_B E_A].$$

Si $E=(-\infty,+\infty)$, alors nous écrivons simplement $\mathfrak{D}_B(f,\varphi)$.

III. Soit $[f]_N = f$ si $|f|\leqslant N$, et $[f]_N = \frac{f}{|f|}N$ si $|f|\geqslant N$.

Théorème 1. *L'espace de fonctions mesurables dont la distance entre deux fonctions est définie par* $\mathfrak{D}_B^E$ *est complet.*

Définition I. L'ensemble $E\subset(-\infty,+\infty)$ est dit relativement dense, s'il existe un nombre fixe $a>0$ tel que $E(x,x+a)$ est non vide pour toute valeur de x.

Définition II. Une suite de nombres $\tau_i (i=0,\pm1,\pm2,\ldots)$ est dite suffisamment uniforme s'il existe un nombre $a>0$ tel que chaque intervalle $(x,x+a)$ contient des points τ_i. De plus, si $\nu(a)$ et $\mu(a)$ désignent resp. le maximum et le minimum du nombre de ces points sur $(x,x+a)$ $[(-\infty<x<+\infty)]$, alors $\frac{\nu(a)}{\mu(a)}<2$.

Définition III (2). $f(x)$ $(-\infty<x<+\infty)$ est dite $\tilde{B}$ presque-périodique ($\tilde{B}$ p. p.) si quel que soit $\varepsilon>0$

1) il existe un nombre $N_0 > 0$ tel que

$$\mathfrak{D}_B(f, [f]_N) < \varepsilon \text{ pour } N > N_0;$$

2) il existe une suite suffisamment uniforme de nombres τ_i ($i = 0, \pm 1, \pm 2 \ldots$) tels que

$$\overline{\lim_{T \to \infty}} \frac{1}{2T} \int_{-T}^{+T} [\overline{\lim_{n \to \infty}} \frac{1}{2n+1} \sum_{i=-n}^{i=+n} \frac{1}{d} \int_{x}^{x+d} |[f(t+\tau_i)]_N - [f(t)]_N| dt] \, dx < \varepsilon$$

(d et N quelconques),

Théorème 2. *La condition nécessaire et suffisante pour la compacité d'un système $\mathfrak{M}(f)$ de fonctions $\tilde{B}$ p. p. consiste en ce que quel que soit $\varepsilon > 0$*

1) *il existe un nombre $\eta > 0$ tel que $\mathfrak{D}_B(f(x+h), f(x)) < \varepsilon$ pour $|h| < \eta$ et cela pour toutes les fonctions du système;*

2) *il existe un nombre $N_0 > 0$ tel que $\mathfrak{D}_B(f, [f]_N) < \varepsilon$ pour $N > N_0$ et cela pour toutes les fonctions du système;*

3) a) *il existe un ensemble relativement dense de nombres (τ) tels que $\mathfrak{D}_B(f(x+\tau), f(x)) < \varepsilon$ pour toutes les fonctions de $\mathfrak{M}(f)$;*

b) *il existe un nombre $b > 0$ et une suite suffisamment uniforme de nombres τ_i tels que*

$$\overline{\lim_{T \to \infty}} \frac{1}{2T} \int_{-T}^{+T} [\overline{\lim_{n \to \infty}} \frac{1}{2n+1} \sum_{i=-n}^{i=+n} \frac{1}{b} \int_{x}^{x+b} |[f(t+\tau_i)]_N - [f(t)]_N| dt] \, dx < \varepsilon$$

pour toutes les fonctions du système $\mathfrak{M}(f)$.

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LITTÉRATURE CITÉE

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PHYSICS

A THEORY OF INTENSITIES AND POLARIZATION IN RAMAN SPECTRA OF HALOGEN SUBSTITUTED METHANES

By M. W. WOLKENSTEIN and M. A. ELIASHEVICH

(Communicated by S. I. Wawilow, Member of the Academy, 12.XI.1943)

In this paper we are reporting the results obtained by applying to the Raman spectra of chlorine and bromine substituted methanes, the theory of intensities and polarization in vibrational spectra of polyatomic molecules, as developed by us [1–3]. The accumulation of experimental data on the molecules of these compounds is rather abundant, but still insufficient for a complete verification of the theory. Quantitative measurements of the intensity and polarization have been made for CH_2Cl_2, $CHCl_3$, CCl_4, CH_2Br_2 and $CHBr_3$ spectra; polarization has also been estimated quantitatively in the spectra of CH_3Cl and CH_3Br. The rest of the available data are of qualitative character. Unfortunately, the use of the results obtained by different authors is in many cases greatly handicapped by the fact that they are not easily comparable to each other. So the task facing now the experimenter is to secure reliable and comparable data on intensities and polarization in the Raman spectra of the above-mentioned and other compounds.

The theory put forward by the authors is built in zero approximation upon the concept of additivity in relation to the properties of the valence bonds. Careful investigation shows, however, that this approximation is not always sufficient. Apart from the polarizability of a bond being a function of its length, it also varies with the length of the neighbouring bonds and with valence angles, so that this dependence must in a number of cases be allowed for by the introduction of special parameters. Proceeding to the next approximation presents no essential difficulties.

In detail the scheme of calculation will be described in the Journal of Physics. The degree of depolarization was computed from the formula

$$\rho = \frac{6B^2}{5A^2 + 7B^2} \tag{1}$$

and the intensity from the formula

$$I = \text{const}\,(5A^2 + 13B^2)\frac{1}{1 - e^{-\frac{h\nu}{kT}}}\frac{(\nu_0 - \nu)^4}{\nu} \tag{2}$$

where ν is frequency of vibrations; ν_0, the exciting frequency (line c of Hg spectrum with $\nu_0 = 22938\ \text{cm}^{-1}$); A and B, the trace and anisotropy of the tensor db_{ik}/dQ. In determining the tensor use was made of the mechanical picture of vibrations —of the potential energy values and the shape of normal coordinates, which B. I. Stepanov [4] had been the first to establish reliably for halogen methanes. The polarizability values for the bonds C—Cl, C—Br and C—H were borrowed from Denbigh [5].

Molecule	Frequency	Form of vibrations	I computed in arbitrary units	I computed in relative units	I measured in relative units		ρ computed	ρ measured	Remarks
					I	II			
1	2	3	4	5	6	7	8	9	10
CCl_4	ω_1 459	$q_x A$	9.0	(10)	(10)	(10)	(0)	0.05	I, Reitz' data [6]
	ω_2 217	μE	11.9	13.2	8.5	9	(6/7)	0.83	II, Shoryguin and Wolkenstein [7]
	ω_3 775	$q_x F$	2.1	2.3	5.0	5.0	(6/7)	0.83	
	ω_4 313	μF	6.3	9.2	9.3	10	(6/7)	6/7	
$CHCl_3$	ω_1 667	$q_x A$	7.5	(10)	(10)	(10)	0.04	0.06—0.13	I, Rao [8]
	ω_2 3020	$q_h A$	1.6	2.1	3.2	3	[0.22]	[0.22]	II, visual estimate
	ω_3 366	$\delta\mu A$	4.2	5.6	9.0	5	0.41	0.19—0.22	ρ, according to authors [10—13]
	ω_4 759	$q_x E$	(14.2?)	(18.8?)	2.3	4	(6/7)	0. 5—0.86	
	ω_5 1214	δE	1.0	1.4	1.5	0	(6/7)	0. 2—0.87	
	ω_6 261	μE	5.6	7.4	11.9	5	(6/7)	0.73—0.87	
CH_2Cl_2	ω_1 700	$q_x A_1$	9.6	(10)	(10)	—	[0.09]	[0.09]	Wagner's data [13]
	ω_2 2986	$q_h A_1$	2.4	2.5	3.1	—	0.11	0.27?	
	ω_3 283	μA_1	6.0	6.3	6.3	—	0.77	0.43	
	ω_4 1418	αA_1	0.7	0.8	0.9	—	0.75	0.88	
	ω_5 3046	$q_h B_1$	1.0	1.0	—	—	(6/7)	D	
	ω_6 896	δB_1	0.8	0.4	—	—	(6/7)	—	
	ω_7 736	$q_x B_2$	2.2	2.3	2.0	—	(6/7)	0.79	
	ω_8 1266	δB_2	0.1	0.1	—	—	(6/7)	—	
	ω_9 1149	δA_2	1.1	0.6	0.5	—	(6/7)	0.89	
CH_3Cl	ω_1 712	$q_x A$	7.3	(10)	(10)	—	[0.2]	[0.2]	Intensity estimated visually, data from Landolt's tables [14]
	ω_2 2957	$q_h A$	3.5	4.8	10	—	[0.05]	[0.05]	
	ω_3 1370	$\delta\alpha A$	0.2	0.3	0	—	0.52	P	
	ω_4 3038	$q_h E$	1.8	2.2	2	—	(6/7)	0.88	
	ω_5 1020	δE	1.2	1.6	0	—	(6/7)	—	
	ω_6 1450	αE	1.6	2.2	2	—	(6/7)	~1	
CH_4	ω_1 2914	$q_h A$	4.2	(10)	(10)	—	(0)	0.08	Visual estimate [15]
	ω_2 1520	αE	1.3	3.2	00	—	(6/7)	—	
	ω_3 3022	$q_h F$	3.8	9.0	2	—	(6/7)	0.8	
	ω_4 1304	αF	0.9	2.2	00	—	(6/7)	—	
CH_3Br	ω_1 595	$q_x A$	8.9	(10)	(10)	—	[0.20]	[0.20]	Visual estimate Landolt's tables [14]
	ω_2 2955	$q_h A$	3.5	3.9	7.5	—	0.05	0.10	
	ω_3 1295	$\delta\alpha A$	0.1	0.1	0.9	—	0.24	P	
	ω_4 3049	$q_h E$	1.8	2.0	1.2	—	(6/7)	0.86	
	ω_5 942	δE	1.4	1.6	00	—	(6/7)	—	
	ω_6 1432	αE	0.8	1.0	0	—	(6/7)	D	
CH_2Br_2	ω_1 577	$q_x A_1$	11.4	(10)	(10)	—	[0.11]	[0.11]	Wagner's data [13]
	ω_2 2988	$q_h A_1$	2.3	2.0	1.6	—	0.11	0.10	
	ω_3 174	μA_1	13.8	12.1	7.6	—	0.77	0.35	
	ω_4 1387	αA_1	0.7	0.6	0.8	—	0.44	0.53	
	ω_5 3001	$q_h B_1$	0.9	0.8	0.1	—	(6/7)	0.85	
	ω_6 806	δB_1	1.7	0.7	—	—	(6/7)	—	
	ω_7 639	$q_x B_2$	3.2	2.8	2.4	—	(6/7)	0.84	
	ω_8 1183	δB_2	0.1	0.1	0.1	—	(6/7)	0.89	
	ω_9 1089	δA_2	1.1	0.5	0.2	—	(6/7)	0.92	
$CHBr_3$	ω_1 539	$q_x A$	9.2	(10)	(10)	—	0.13	0.06—0.13	Visual estimate ρ, according to authors [10,11,15]
	ω_2 3021	$q_h A$	1.5	1.6	5.7	—	0.22	0.22—0.3	
	ω_3 222	μA	6.9	7.5	11.4	—	0.39	0.11—0.22	
	ω_4 655	$q_x E$	(22.0?)	(24.0?)	7.2	—	(6/7)	0. 5—0.7	
	ω_5 1144	δE	0.6	0.8	2.9	—	(6/7)	0. 5—0.86	
	ω_6 154	μE	9.0	9.8	8.6	—	(6/7)	0.77—0.8	
CBr_4	ω_1 265	$q_x A$	9.9	(10)	(10)	—	(0)	—	Visual estimate [15]
	ω_2 125	μE	20.2	20.3	10	—	(6/7)	—	
	ω_3 667	$q_x F$	0.8	0.8	2	—	(6/7)	—	
	ω_4 183	μF	14.5	14.6	8	—	(6/7)	—	

Note. The values used are enclosed in a frame.

In zero approximation the determination of the intensity and polarization of chlorine and bromine substituted methanes implies, moreover, the knowledge of another six quantities—the differential quotients of the longitudinal and transverse polarizabilities by the bond length for the bonds C—Cl, C—Br, C—H. These six unknowns were found by means of the six equations (1), expressing the degree of depolarization of the symmetric valence vibrations: $\omega_2$3020 $CHCl_3$ and ω_2 2957 CH_3Cl for the C—H bond; ω_1 700 CH_2Cl_2 and ω_1 712 CH_3Cl for the C—Cl bond; ω_1 577 CH_2Br_2 and ω_1 595 CH_3Br for the C—Br bond. By means of these six quantities the remaining 14 values of ρ and 54 intensities were computed. The unknowns can also be determined from other combinations of experimental data, but we had to choose the most reliable and comparable among them. The values obtained by us for the unknowns are as follows (in 10^{-16} cm^2): C—Cl bond: $\alpha'_1 = 2.82$, $\alpha'_2 = 0.68$; C—Br bond: $\alpha'_1 = 3.23$, $\alpha'_2 = 0.83$; C—H bond: $\alpha'_1 = 1.37$, $\alpha'_2 = 0.30$.

It should be emphasized that these numerical values are rather arbitrary, since they depend very strongly on the values of ρ and the magnitude of $\alpha_1 - \alpha_2$ which have not been always determined with sufficient accuracy. The computed and the measured values of I and ρ are brought together in the adjoined table. In column 4 are given the intensities expressed in arbitrary units according to formula (2) and thereby comparable to each other. The computed values in column 5 are comparable within the limits of the respective molecules and reduced to the value placed in parentheses. Their corresponding values determined by experiment are listed in column 6. In column 7 those values are put in parentheses which result from the properties of symmetry and are independent of our theory.

The study of these data leads to the following conclusions:

1. In general, the theory of zero approximation gives a satisfactory agreement between the measured and computed values for the intensity and polarization, or, at any rate, presents them in a correct sequence.

2. The course of the intensity is reproduced better than that of the polarization, because the values of the former are more strongly influenced by the form of vibrations, accurately determined (4).

3. The calculated degree of depolarization is higher in the deformational vibrations (Nos. 13, 38, 47) than in the experimental ones. This is owing to the insufficiency of the zero approximation in those cases where the rôle of the terms involving $\partial\alpha/\partial\gamma$ is particularly significant [cf. (3)].

4. Special interest attaches to the properties of the C—H bond. The values of polarizability α_1 and α_2 are here naturally small, because small is also the volume of the electronic cloud. Contrary to this, the variation of these values with increasing bond length is very considerable because of the homeopolar character of the bond; the value of $\partial\alpha/\partial r$ is the lower, the more ionic the character of the bond.

5. The actual values of $\partial\alpha/\partial r$ for the C—H bond are probably even higher than those found by us. This accounts for the computed intensities of the valence C—H frequencies (Nos. 21, 26, 31, 46) being lower than the experimental ones. The inaccuracy here is due to the fact that the value of $\alpha_1 - \alpha_2$(5) used by us is in doubt.

Laboratory of Spectrum Analysis,
State Optical Institute.

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PHYSIQUE APPLIQUÉE

LE PROBLÈME DE MISES DANS LA THÉORIE DE LA RÉGULATION DIRECTE ET LA THÉORIE DES TRANSFORMATIONS PONCTUELLES DES SURFACES

Par A. ANDRONOW et A. MAYER

(Présenté par L. I. Mandelstam, de l'Académie, le 8.II. 1944)

Nous étudions, en faisant les simplifications usuelles, le mouvement d'un système machine—régulateur dont le frottement obéit à la loi de Coulomb.

Ce cas particulier du problème de la régulation directe a été l'objet de nombreux travaux ([2-14]). Nous l'appellerons problème de Mises. L'application à ce problème non-linéaire de la théorie des transformations ponctuelles des surfaces conduit à un ensemble de résultats dont certains sont nouveaux et d'autres ont été obtenus précédemment, notamment par Mises, par des procédés graphiques et numériques.

1. Soit x le déplacement du manchon du régulateur; y, la variation de la vitesse angulaire de la machine; A, la quantité dite «premier paramètre principal de régulation directe*».

Nous avons le système:

$$\frac{dx}{dt}=z; \quad \frac{dy}{dt}=-x; \quad \frac{dz}{dt}=F(x,y,z)$$

où

$$F(x,y,z,)=\begin{cases} -Ax+y-{}^1/_2 \text{ si } z>0 \text{ ou } z=0,\ -Ax+y>{}^1/_2 \\ -Ax+y+{}^1/_2 \text{ si } z<0 \text{ ou } z=0,\ -Ax+y<-{}^1/_2 \\ 0 \quad \text{si } z=0,\ -{}^1/_2\leqslant -Ax+y\leqslant {}^1/_2 \end{cases} \tag{1}$$

La solution du système est déterminée par les conditions initiales pour $t=0$: $x=x_0$**, $y=y_0$, $z=0$, et la condition de continuité des fonctions $x(t)$, $y(t)$, $z(t)$ aux points de discontinuité de $F(x;y,z)$.

Soient $-2p$, $p\pm qi$ les racines de l'équation caractéristique du système linéaire que devient (1) lorsque $F(x,y,z)=-Ax+y$, et posons $p=qc$, $qt=t'$, $x=q\xi$, $y=\eta$, $z=q^2\zeta$***.

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* Le paramètre sans dimensions A est lié aux grandeurs employées ordinairement dans la théorie de la régulation par la relation

$$A=\delta\sqrt[3]{\frac{4T_0^2}{T^2}}$$

δ étant le coefficient d'irrégularité théorique du régulateur; T_0, la durée de mise en marche de la machine; T, la durée de chutte libre du manchon du régulateur. Voir pour plus de détails ([1]), ([12]).

** La constante x_0 est liée avec les grandeurs employées dans la théorie de la régulation par la relation $\frac{1}{|x_0|}=\frac{\varepsilon}{\lambda}\sqrt[3]{\frac{4T_0^2}{T^2}}$, ε étant «l'insensibilité du régulateur»; λ, la «variation relative du couple résistant» de la machine ([12]).

*** Remarquons que $0<p<\frac{q}{\sqrt{3}}$ et $A=\frac{1-3c^2}{\sqrt[3]{4c^2(1+c^2)^2}}$.

L'équation (1) détermine une transformation du plan $\xi, \eta (\zeta = 0)$ en lui-même.
Divisons le plan $\xi, \eta (\zeta = 0)$ en trois morceaux (fig. 1):
$G^{(1)}$, où $-Aq\xi + \eta > {}^1/_2$ ou $-Aq\xi + \eta = {}^1/_2$, $\xi < 0$;
$G^{(2)}$, où $-Aq\xi + \eta = {}^1/_2$, $\xi > 0$ ou $-{}^1/_2 < -Aq\xi + \eta < {}^1/_2$ ou $-Aq\xi + \eta = -{}^1/_2, \xi < 0$;
$G^{(3)}$, où $-Aq\xi + \eta < -{}^1/_2$ ou $-Aq\xi + \eta = -{}^1/_2$, $\xi > 0$.

Si le point initial $\xi = \xi_0$, $\eta = \eta_0$ appartient à $G^{(2)}$, il devient en vertu de (1), lorsque $\xi_0 > 0$, le point $\xi_1 = \xi_0$, $\eta_1 = Aq\xi_0 - {}^1/_2$ du morceau $G^{(3)}$, et lorsque $\xi_0 < 0$, le point $\xi_1 = \xi_0$, $\eta_1 = Aq\xi + \frac{1}{2}$ du morceau $G^{(2)}$. La transformation du point ξ_0, η_0 du morceau $G^{(2)}$ en le point ξ_1, η_1 sera dite transformation E.

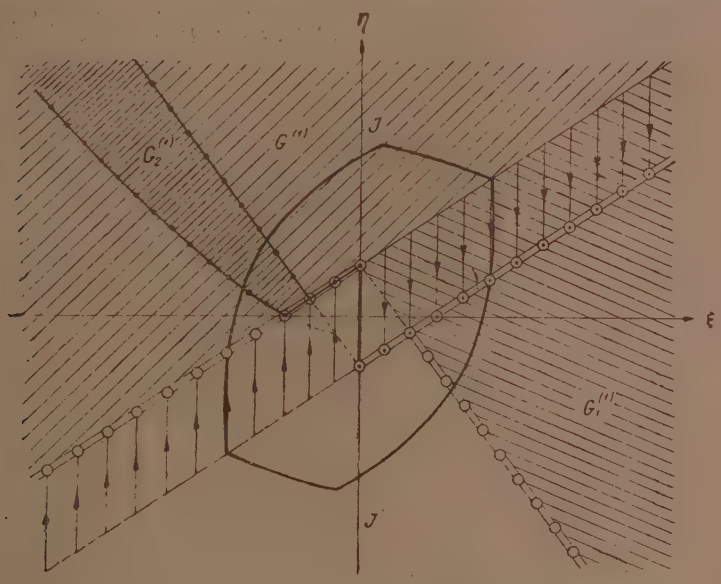

Fig. 1

Si le point initial $\xi_0, \eta_0 (t' = 0)$ appartient à $G^{(1)}$ ou $G^{(3)}$, $\tau > 0$ désignant la valeur la plus proche de t' pour laquelle de nouveau $\zeta = 0$, et ξ_1, η_1 les valeurs correspondantes de ξ et η, on a

$$\xi_0 = \varrho f(\tau), \quad \eta_0 + R = \varrho g(\tau), \tag{2}$$
$$\xi_1 = -\varrho e^{-2c\tau} f(-\tau), \quad \eta_1 + R = -\varrho e^{-2c\tau} g(-\tau) \tag{3}$$

où

$$f(\tau) = (1 + c^2) \left\{ \cos \tau + \frac{1 + 3c^2}{2c} \sin \tau - e^{-3c\tau} \right\}$$
$$g(\tau) = -2c \cos \tau + \frac{1 + 6c^2 - 3c^4}{4c^2} \sin \tau + 2ce^{-3c\tau}.$$

Les formules (2) et (3) expriment, sous forme paramétrique, lorsque $R = -{}^1/_2$, $0 < \varrho < +\infty$, la transformation du point ξ_0, η_0 du morceau $G^{(1)}$ en le point ξ_1, η_1 appartenant à $G^{(2)}$ ou $G^{(3)}$ (transformation S^+), et lorsque $R = +{}^1/_2$, $0 > \varrho > -\infty$, la transformation d'un point de $G^{(3)}$ en un point appartenant à $G^{(1)}$ ou $G^{(2)}$ (transformation S^-). Cela étant, le paramètre τ peut prendre toutes les valeurs comprises dans l'intervalle $(0, \theta)$, θ étant la plus petite des racines positives de l'équation

$$e^{-3c\theta} = \cos \theta - 3c \sin \theta. \tag{4}$$

Il s'agit d'étudier la transformation du plan ξ, η en lui-même constituée par l'ensemble des transformations S^+, S^-, E^*.

2. La transformation que nous étudions ne déplace pas les points du segment $\xi = 0, -{}^1/_2 \leqslant \eta \leqslant +{}^1/_2$. C'est pourquoi nous appellerons celui-ci segment de repos.

La condition de stabilité en petit est pour le segment de repos

$$e^{-c\vartheta} > c \sin\theta - \cos\theta \quad (\text{soit } A > 1.2531).$$

Le même résultat numérique, mais dans une interprétation quelque peu différente, a été obtenu par Mises et d'autres auteurs [v. par. ex. ([12])].

3. Admettons que le point $P(\xi_0, \eta_0)$ $(\varphi = \varphi_0, \tau = \tau_0)$ du morceau $G^{(1)}$ se transforme en le point $P_1(\xi_1, \eta_1)(\varphi = \varphi_1, \tau = \tau_1)$ du morceau $G^{(3)}$, et ensuite en le point $\xi_2 = \xi_0$, $\eta_2 = \eta_0$.

On a alors

$$\begin{gathered} -\varphi_0 e^{-2c\tau_0} f(-\tau_0) = \varphi_1 f(\tau_1); \ \varphi_0 f(\tau_0) = -\varphi_1 e^{-2c\tau_1} f(-\tau_1) \\ -\varphi_0 e^{-2c\tau_0} g(-\tau_0) + {}^1/_2 = \varphi_1 g(\tau_1) - {}^1/_2 \\ \varphi_0 g(\tau_0) + {}^1/_2 = -\varphi_1 e^{-2c\tau_1} g(-\tau_1) - {}^1/_2 \end{gathered} \tag{5}$$

L'étude du système (5) montre qu'il ne possède que des solutions telles que $\tau_0 = \tau_1 = \tau^*$, $\varphi_0 = -\varphi_1 = \varphi^*$.

La valeur $\tau = \tau^*$ est déterminée par l'équation

$$\operatorname{sh} 2c\tau + \operatorname{sh} c\tau \cos\tau + \frac{1 + 3c^2}{2c} \operatorname{ch} c\tau \sin\tau = 0. \tag{6}$$

Pour $A < 1.2531$ cette équation n'a pas de solution, et par conséquent le mouvement considéré n'existe pas. Pour $A > 1.2531$ cette équation possède une solution et une seule.

4. L'étude de l'équation caractéristique du point P montre que c'est un col. Cela signifie en particulier que les points qui, lorsque la transformation est réitérée, se rapprochent indéfiniment de P, sont situés sur deux courbes L_1 et L_2 (ω-séparatrice du col) formant avec P une courbe analytique en P; les α-séparatrices de P forment également avec P une courbe L. Dans le morceau $G^{(3)}$ symétriquement à P, L_1, L_2 et L par rapport à l'origine se trouvent le col $P' \equiv P_1$ et les séparatrices correspondantes.

5. Nous commencerons l'étude de la structure globale de l'extension en phase en examinant à l'aide de la transformation de Poincaré la conduite des points du plan ξ, η suffisamment éloignés. Posons

$$z = \frac{1}{\eta} = \frac{w}{g(\tau) - Rw}, \qquad u = \frac{\xi}{\eta} = \frac{f(\tau)}{g(\tau) - Rw} \tag{7}$$

où $w = \frac{1}{v}$. Les formules (2) et (3) déterminent une transformation du plan z, u en lui-même telle que l'axe $z = 0$, qui se transforme en lui-même, correspond à la droite infiniment éloignée du plan ξ, η (équateur de la sphère de Poincaré).

L'étude de (7) et de la transformation analogue que l'on obtient pour $z = \frac{1}{\xi}$, $u = \frac{\eta}{\xi}$ montre qu'il existe sur l'équateur de la sphère de Poincaré deux points invariants seulement, qui correspondent à $w = 0$, $\tau = \pi$ et sont des noeuds stables.

Transportons l'étude sur une des hémisphères de Poincaré.

La partie $G^{(1)}$ de l'hémisphère devient, par la transformation S^+, un certain ensemble $G_1^{(1)}$ dont les points appartiennent à $G^{(2)}$ et $G^{(3)}$. Appliquant aux

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* Il y a avantage dans l'étude de la transformation (2), (3) de distinguer deux cas: 1) défaut de régulation, lorsque $f(-\vartheta) < 0$ (soit $A > 2.623$), et 2) excès de régulation, lorsque $f(-\vartheta) > 0$ (soit $A < 2.623$).

points $G_1^{(1)}$ les transformations E et S^-, on obtient un certain ensemble de points $\overline{G}_2^{(1)}$ contenant le domaine $G_2^{(1)}$ compris dans $G^{(1)}$. L'étude de la conduite des points $\overline{G}_2^{(1)}$ non compris dans $G_2^{(1)}$ et de celle des points du domaine $G_2^{(1)}$ [effectuée à l'aide d'un artifice permettant d'utiliser les raisonnements de Brouwer (15)] conduit aux conclusions suivantes:

a) si $A < 1.2531$, tous les points du plan sauf ceux du segment de repos s'éloignent à l'infini lorsque la transformation est réitérée;

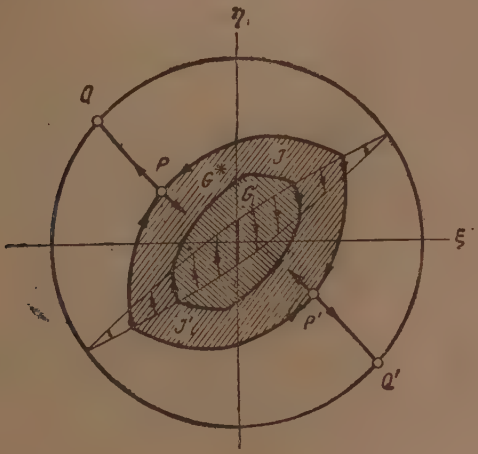

Fig. 2

b) si $A > 1.2531$, les ω-séparatrices des cols P et P' limitent un ensemble ponctuel* G^* tel que, si le point initial appartient à G^*, les points transformés tendent vers le segment de repos, et si le point initial n'appartient ni à G^* ni à sa frontière, les points transformés s'éloignent à l'infini.

Il résulte de ces conclusions que sauf P, P' et le segment de repos il n'existe pas de points non-errants [terminologie de Birkhoff(16)] dans une partie finie du plan.

6. Comme nous l'avons montré plus haut, le processus de régulation converge à deux conditions: 1) $A > 1.2531$; 2) les valeurs initiales sont comprises dans G^*.

D'après Joukovski(9), il faut mettre à la base des calculs techniques des régulateurs non pas G^*, mais une partie G de cet ensemble (G est appelé «domaine de Joukovski») pour les points de laquelle les accélérations «initiales» à partir de la deuxième transition sont nulles (et les points transformés sont par conséquent compris dans $G^{(2)}$).

A partir de (2), (3) on peut facilement écrire les équations paramétriques de la frontière du domaine de Joukovski (courbes I et I' des fig. 1 et 2). Nous indiquons ici cette frontière seulement pour un cas spécial de conditions initiales, le plus important pratiquement: $x = x_0$, $y = Ax_0$, $z = 0$. Dans ce cas la détermination de la frontière se réduit à celle de la valeur frontière correspondante de x_0.

Pour représenter les relations ayant lieu dans ce cas, on se sert ordinairement de plan de Mises, portant A en abscisse et $\beta = \frac{1}{|x_0|}$ en ordonnée.

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* G^* est un domaine simplement connexe, si la ω-séparatrice de P coupe la frontière correspondante de G^* en un seul point. Les constructions graphiques de Mises montrent que c'est ce qui a lieu effectivement. La théorie montre que toute autre hypothèse amène une complication incroyable: G peut devenir multiplement connexe et même se décomposer en un nombre fini de domaines. Mais dans l'extension en phase à trois dimensions ξ, η, ζ le domaine d'attraction du segment de repos reste toujours simplement connexe.

Sur ce plan le domaine des valeurs de A, β, qui convient d'après Joukovski au fonctionnement du régulateur; est limité par la droite $A = 1.2531$ et la courbe $\beta = \frac{1}{q} e^{c\theta} |\sin \theta|$, θ étant déterminé par l'équation (4).

Institut Physico-Technique.
Université de Gorki.

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CHEMISTRY

ON THE NATURE OF CHEMICAL BOND IN AMINOPYRIDINE COMPLEX COMPOUNDS OF PLATINUM

By A. M. RUBINSTEIN

(Communicated by I. I. Černjaiev, Member of the Academy, 14.X.1943)

The complex compounds of platinum with aminopyridine have been found by me (1) to differ greatly in properties from those with pyridine and ammonia-pyridine. Compared to the pyridine compounds those with aminopyridine are more stable. This becomes apparent with particular clearness when the properties of aminopyridine tetramine of platinum, $(AmPy)_4PtCl_2$, are investigated. This compound when heated up to 105—110° C undergoes no decomposition whatever, while ammonia and pyridine tetramines are decomposed at this temperature with separation of ammonia and pyridine. The higher stability of the aminopyridine tetramine is apparently connected with the nature of the chemical bond between

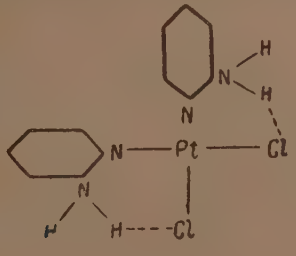

Fig. 1

aminopyridine and platinum. Considerable interest attaches therefore to the question as to the character of this bond. Thus far no such difference has been observed on studying the stability of different tetramines of platinum.

All investigations of ammonia and pyridine complex compounds of the A_2Cl_2Pt type have invariably shown that ammonia and pyridine are linked with platinum through nitrogen. If one proceeds on the assumption that the bond between pyridine and platinum is essentially a dipole bond, a nearly equal stability of pyridine and aminopyridine complex compounds might be presumed on the ground that the dipole moments of pyridine and aminopyridine are close to each other. Pyridine is a dipole molecule with a moment equal to 2.23 Debye. The negative end of the dipole is on the nitrogen side. Aminopyridine is a dipole molecule with a moment equal to 1.9—2.17 Debye (according to temperature). However, the nature of the chemical bond of pyridine and aminopyridine with platinum should not be referred entirely to the dipole type of linkage. We know of molecules having a large dipole moment and yet forming no complex chemical bond. Such is nitric methane,

for instance, with its 3.56 Debye ([2]). Therefore we may take it for granted that the bond of pyridine and aminopyridine is not a purely dipole type. We may suppose that the stability of aminopyridine complex compounds is due to the fact that upon its entering the inner sphere of the complex compound, aminopyridine has its chemical bond with platinum established through tertiary nitrogen and forms moreover an additional, the so-called «hydrogen bond», whereby the hydrogen of the aminogroup is linked with chlorine according to the scheme presented in Fig. 1.

As will be shown later, the formation of the intramolecular hydrogen bond goes far to increase the stability of the molecule.

The bond with hydrogen is not a strong bond. The energy of the reaction $XH + Y \rightarrow XHY$ giving rise to the hydrogen bond is about 5 kg·cal./mole as an average, whereas in the case of an ordinary chemical bond the energy may range through the following figures: 18 kg·cal./mole for the P—P bond, 15 for As—As, 20 for N—N, 57.8 for Cl—Cl, 63.5 for F—F, 87.5 for H—Br, 103.4 for H—H, 110.2 for O—H, and 147.5 for H—F.

The energy values of the hydrogen bond can be set out in tabular form as follows ([3]) (Table 1).

Table 1

Bond	Substance	Bond energy kg·cal./mole
O—H— — —O	H_2O (ice)	4.5
O—H— — —O	CH_3OH, C_2H_5OH	6.2
O—H— — —O	$(CH_3COOH)_2$	8.2
C—H— — —N	$(HCN)_2$	3.28
C—H— — —N	$(HCN)_3$	4.36
N—H— — —N	NH_3	1.3
N—H— — —F	NH_4F	5
O—H— — —Cl	OC_6H_4OHCl	3.9

The energy of the hydrogen bond depends upon the chemical nature of the atoms that form the bond, upon interatomic distances and the individual properties of the molecules concerned.

The values of the interatomic distances in the case of hydrogen bond formation are tabulated below (Table 2).

Table 2

Bond	Substance	Observed distances A—H— — —B in Å ([4])
F—H— — —F	KHF_2	2.26
O—H— — —O	H_2O	2.76
O—H— — —O	$(HCOOH)_2$	2.67
O—H— — —O	H_3BO_3	2.71
O—H— — —O	$(COOH)_2$	2.6
N—H— — —N	NH_3	3.38
N—H— — —F	NH_4F	2.63
N—H— — —O	$CO(NH_2)_2$	2.98
N—H— — —Cl	C_6H_4OHCl	1.9

As a result of numerous investigations a great number of compounds have been found to involve a hydrogen bond materialized by a hydrogen atom having on either side one of the following atoms: oxygen, nitrogen, fluorine, carbon ([5]), chlorine, bromine, iodine *etc.* ([6]). The pair of atoms between which lies the hydrogen atom may either belong to a single molecule, and then we have the so-called

intramolecular hydrogen bond, or to different molecules, in which case the bond is said to be intermolecular.

In spite of a considerable accumulation of experimental data on the hydrogen no theory of hydrogen bond has won itself as yet general recognition. The theoretical interpretation of this subject has mainly developed along three different lines:

1) The theory of Latimer and Rodebusch (7) considers the hydrogen bond in the light of Lewis' theory.

2) According to the coordination theory of Sidgwick (8), the formation of compounds is connected with the existence among electrons of donors and acceptors. It ascribes to hydrogen special coordination properties, establishes the existence of bivalent hydrogen, and in this connexion assumes that the hydrogen bond is brought about by two electrons. This theory is incompatible with the evidence obtained by means of quantum-mechanical computations.

3) By the electrostatic theory of Pauling (9), the phenomenon of hydrogen bond is reduced to electrostatic interactions.

None of these theories can claim to give a complete interpretation of the hydrogen bond.

If an attempt be made to calculate the possibility for the formation of a hydrogen bond in a complex compound of platinum with an aminopyridine having a cis-configuration, it will be found that such a bond is indeed possible. This bond will be established between the hydrogen of the aminogroup and the chlorine, according to the scheme shown in Fig. 1.

If the molecule of aminopyridine is supposed to be arranged in a plane, one may calculate the distance between the hydrogen of the aminogroup and the chlorine (indicated in the scheme by a dotted line), and thus establish the possibility for the formation of the hydrogen bond in our complex compound with aminopyridine.

Engel's roentgenoscopic investigations (10) of different compounds have secured the following values for the distance between platinum and chlorine:

K_2PtCl_6	$(NH_4)PtCl_6$	$RbPtCl_6$	Cs_2PtCl_6	K_2PtCl_4
2.33 Å	2.36 Å	2.32 Å	2.34 Å	2.32 Å

On the basis of these data the distance between platinum and chlorine in our compound can be put at 2.32 Å. The distance between the platinum atom and the tertiary nitrogen of the aminopyridine can be computed from the fact that the covalent radius of the platinum atom is 1.31 Å and that of the nitrogen atom is 0.7 Å. Therefore the distance between platinum and nitrogen atoms may be estimated as 2 Å. In determining the distance between the nitrogen and the carbon, the data of Brockway and Norman (11) can be made use of. They found this distance to be 1.4 Å; the angle of this bond with the platinum-nitrogen bond as estimated by them is 60°. On this basis we can take 1.4 Å for the distance between the tertiary nitrogen and carbon, and for that between the carbon and the nitrogen of the aminogroup.

From the nitrogen of the aminogroup two bonds of nitrogen and hydrogen proceed at an angle of 109° (a tetrahedral angle). The distance between the nitrogen and hydrogen atoms is 1.08 Å. If the distances thus found are drawn at the respective angles, it will appear that the distance between the chlorine and the hydrogen of the aminogroup is 1.12 Å.

In order for a hydrogen bond between the hydrogen and chlorine to be established a distance of 1.9 Å is necessary. This distance is materialized in the molecule by the hydrogen atoms turning about the bond N—H, for hydrogen tends to assume the most favourable position in point of energy, when the intramolecular hydrogen bond is formed.

As we have two aminopyridine molecules in our compound $(AmPy)_2Cl_2$ Pt, two hydrogen bonds will form. Taking the average energy involved in the formation of a hydrogen bond to be equal to 5 kg. cal./mole, we have a gain of 10 kg. cal./mole when two hydrogen bonds are formed in our compound. This gain may

strongly stabilize the molecule and impart a greater stability to the inner sphere substituents, which is actually observed in studying aminopyridine complex compounds.

From what has been said here we come to the conclusion that α-aminopyridine, while entering the inner sphere, forms an ordinary bond with platinum by means of tertiary nitrogen, and in addition an intramolecular hydrogen bond between

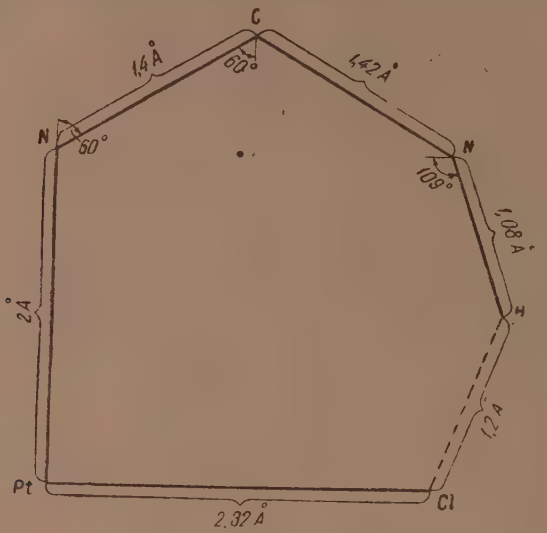

Fig. 2

the hydrogen of the aminogroup and the chlorine is established. This explains why we have found the aminopyridine to have an increased stability while in the inner sphere of a complex compound of platinum. The presence of a hydrogen bond in these compounds I intend to check experimentally by studying the infra-red spectra of complex compounds with aminopyridine.

Institute of General and Inorganic Chemistry.
Academy of Sciences of the USSR.

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MINERALOGY

SYNTHESIS AND STUDY OF PHLOGOPITE

By D. P. GRIGORIEV

(Communicated by D. S. Beliankin, Member of the Academy, 25.X.1943)

The phlogopites, synthetically prepared and described by this author in 1934—1935, were produced in the presence of calcium fluoride ([1—3]), owing to which their chemical composition is distinguished by the presence of the calcium component *. In this paper a method for producing purely magnesial fluor-phlogopite**, without any admixture of the calcium compound, is described.

For the synthesis of pure fluor-phlogopite there was used a charge consisting of a mixture of chemical reagents—K_2CO_3, MgO, Al_2O_3 and SiO_2, taken in a ratio corresponding to the theoretical composition of this mineral; to this charge 25 per cent ammonium fluoride was added (*i. e.* 13.6 per cent F); in the course of the experiment the excess of volatiles—CO_2 and NH_3 —was volatilized, as well as a part of the fluorine (see chemical analysis).

The smelting was carried out in a common cryptol furnace in a coal crucible holding about 20 g of the charge, at a temperature of about 1350° C when the melt would become quite liquid. The synthesis was carried out many times.

The melts produced in external appearance consist completely of mica scales, with an area up to 10 mm^2. The coloration of the mica taken as a whole is white, but individual scales are transparent and colourless, with a vitreous lustre, in part resembling the pearly one.

Following the cleavage planes thin mica scales are split off, possessing flexibility and elasticity, but to a somewhat lesser degree than natural phlogopite; they can be cut with scissors. The hardness of the mineral is 2.5—3.

In some melts, in voids, well-formed crystals of phlogopite have been formed, up to 2 mm across, and 0.1—0.2 mm thick. The crystals are perfectly transparent and colourless. The shape of the crystals of artificial phlogopite corresponds to that of the analogous natural mineral, *i. e.* from the common standpoint it is a combination of pinacoids {001}, {010} and a rhombic prism {110}.

Under the microscope, on the largest crystal the angles between all the faces were measured. Within the error of observation, all of them were found to be similar, namely 120°.

To determine the chemical composition of the mica produced, one of the melts was crushed, and from this, under a binocular magnifying glass transparent scales of this mineral were selected. The chemical analysis yielded the results which are presented in the table below.

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* The chemical constitution of synthetic Ca-bearing phlogopites is considered in detail in ([4,5]).

** The name of «fluor-phlogopite» is already being used in reference literature ([6]).

Determinations*	Melt No. 327, weight %
SiO_2	41.71
Al_2O_3	14.39
MgO	28.62
K_2O	8.98
F	9.80
Total	103.50
$-O=F_2$	3.90
	99.60

* Analysts: D. P. Grigoriev and E. N. Egorova (determination of fluorine).

From the results of the analysis, the following molecular ratios of the components of synthetic phlogopite are calculated (upon assuming the amount of silica as 6):

$$4.08\ F;\ 0.90\ K_2O;\ 6.12\ MgO;\ 1.23\ Al_2O_3;\ 6.00\ SiO_2.$$

The ratio corresponds closely enough to the normal formula of fluor-phlogopite:

$$F_2KMg_3\ [AlSi_3O_{10}].$$

The deviations do not exceed the variations for the figures of analyses of natural micas. A small excess of fluorine seems to be partly compensated by a likewise small excess of magnesium in the cationic part, and of aluminium in the anionic part of the compound.

The shape of phlogopite sections in slides is that of laths between which there are located areas with different sections. A very fine cleavage is perfectly visible along the elongations of the laths. The mica is, of course, perfectly transparent and colourless.

The refractive indices of the mica (determined by the immersion method in an open petrographic thin-section) are as follows: $N_g = 1.554$, $N_p = 1.518$. The calculated birefringence is $N_g - N_p = 0.036$.

In the conoscope, the mica lamellae, oriented with their cleavage plane perpendicular to the optic axis of the microscope, and individual crystals behave like uniaxial crystals with a negative optic sign. Thus, in a common examination the $2V$ angle of artificial phlogopite is found to be 0°. The N_p axis is perpendicular to the cleavage plane of mica.

From the description it will be seen that the synthetically produced combinations actually are pure phlogopite, *i. e.* magnesial mica, corresponding to the «solvent» of complex isomorphous compounds of the group of magnesial-ferruginous micas.

The synthesis described is of interest from the standpoint of the possibilities which it affords for the experimental investigation of the chemistry and properties of micas of the phlogopite series.

The experiments already described permit the following new points to be established.

1. A stable combination of fluorine in the melt to the phlogopite molecule upon its introduction to the charge in the form of such a very readily volatile compound as ammonium fluoride.

2. A higher optic symmetry of artificial phlogopite—corresponding to the system—than that of natural phlogopite referred to the monoclinic symmetry*.

* Strictly speaking, the deviations of optic nature of natural phlogopites from the requirements of the hexagonal system do not exceed those optic anomalies which are in general observed in uniaxial minerals (7).

These new observations are in agreement with the data of old mineralogists on the hexagonal symmetry of magnesial micas ([8]—[11]).

3. The necessity of a careful diagnostication of light micas in calcareo-magnesial silicate hornstones as «muscovites», since pure phlogopites, like the described artificial one, are quite colourless and in outward appearance are hardly distinguishable from muscovite *. It seems that it is this confusion that has caused the view as to the possibility of finding in the hornstones mentioned muscovites with an optical angle near 0° [*e. g.* V. N. Lodochnikov in ([13])]. Such conditions of occurrence genetically correspond to phlogopite rather than to muscovite.

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* Cf. the diagram of coloration of magnesial-ferruginous micas ([12]) prepared by the present author and A. V. Kotulsky.

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BIOCHEMISTRY

VIABILITY OF A RIPE WHEAT GRAIN AS AFFECTED BY HEATING UNDER CONDITIONS OF VARYING MOISTURE CONTENT

By A. I. SMIRNOV, Corresponding Member of the Academy

Unfavourable storing conditions of a perfectly ripe seed do not infrequently lead to its excessive moisture content, which may easily deprive it of its viability.

Among the methods for artificial grain drying thermal exsiccation is the most widely applied. No adequate drying of grain can possibly be achieved unless one is duly informed as to the resistance of the grain to heating, which is dependent on the length and temperature of the treatment and varies according to the dampness of the grain. It stands to reason therefore that the investigation of the heating of ripe grain when damp is of practical importance.

In the case of thermal treatment of damp grain its heating proceeds along with a loss of humidity. The relation between the rate of heating and that of dehydration of the grain is liable to considerable variations, which depend on the conditions of air supply and on the rate of the temperature rise. And it is no easy matter to determine with sufficient accuracy the mode of correlation between the heat-resistance of the grain and its moisture content (1). In order to bring out this relation, we found it expedient to subject to testing such grain as was likely to possess a constant moisture content throughout the period of heating. The temperature thresholds thus obtained up to which a grain of a definite moisture content may withstand heating would warrant for its complete viability, when subjected to thermal treatment.

The viability of a grain may directly be evaluated from its germinating power. In so far as the latter seems to be (1) intimately related to the grain's respiration, it is of interest to study along with the influence of heating upon the grain's viability, the changes that take place in its gas-exchange, as well.

Method. As testing material use was made of fully ripe grains of summer-wheat, variety *Lutescens* 062, that went through after-ripening. Their germination capacity was determined by Heinrich's method in quartz sand, the seeds being planted 3 cm deep. The respiratory gas-exchange was recorded with the aid of a manometer (2). The germinating capacity was determined at indoor temperature (20° C), at two replications*, each determination involving 100 grains. It was also calculated from pair determinations. Each respirometer of the manometer was made to contain 10—20 g of grain, according to the degree of the latter's dampness. The time of exposure was 1 hour. The moisture content of the grain was brought up to about 18, 25 and 30 per cent. The dampness of the grain actually obtained was found to deviate from the figures known by 0.5 per cent. Samples of air-dry wheat grains were placed in small Erlenmeyer flasks in a thin layer and wetted with such an amount of water as to make the grain sufficiently damp. In order to determine the amount of water needed, the moisture of an air-dry grain was

* The coleoptyles popping through the sand were recorded by the tenth day upon planting.

preliminarily determined in a special sample. The seeds usually took from 2 to 3 hours to absorb the water additionally supplied. To obtain uniform distribution of the water throughout the grain, and an equilibrium between the free and the colloidally bound water in the grain ([3]), the latter was kept upon wetting in stopped Erlenmeyer flasks for about one day (from 5 o'clock p. m. until 2 p. m. of the next day).

The grains wetted were subjected to heating in the same flasks at 40, 50 or 60° C.

After the temperature appointed for a given test had been attained, the flasks with the grain they contained were heated during 5, 10, 20, 30, 60 or 90 minutes, respectively. Within the time of heating under such conditions, the moisture of the grain decreased but little, by some 0.37—1.48 per cent within 0.5—1.5 hour. Upon heating the grain was exsiccated until air-dry during a day in the open air, at the laboratory. Part of the grain so dried was planted into wet sand (15 per cent moisture content) in order to test its germinating capacity. Another portion was used to determine its respiratory gas-exchange after it was brought again to the moisture content it had when heated and preliminarily kept in stopped flasks for about a day ([3]).

Results. The viability of the grain that was to be heated could be estimated after the respiratory gas-exchange of the control samples that were subjected to no heating, but were wetted up to the same moisture content as that of the experimental grain (Table 1).

Table 1

Respiratory Exchange in Grain as Dependent on Moisture Content in mm^3 of O_2 and CO_2 per 1 g of abs. Dry Grain, within 1 hour at 25°C (determined by Ushakova)

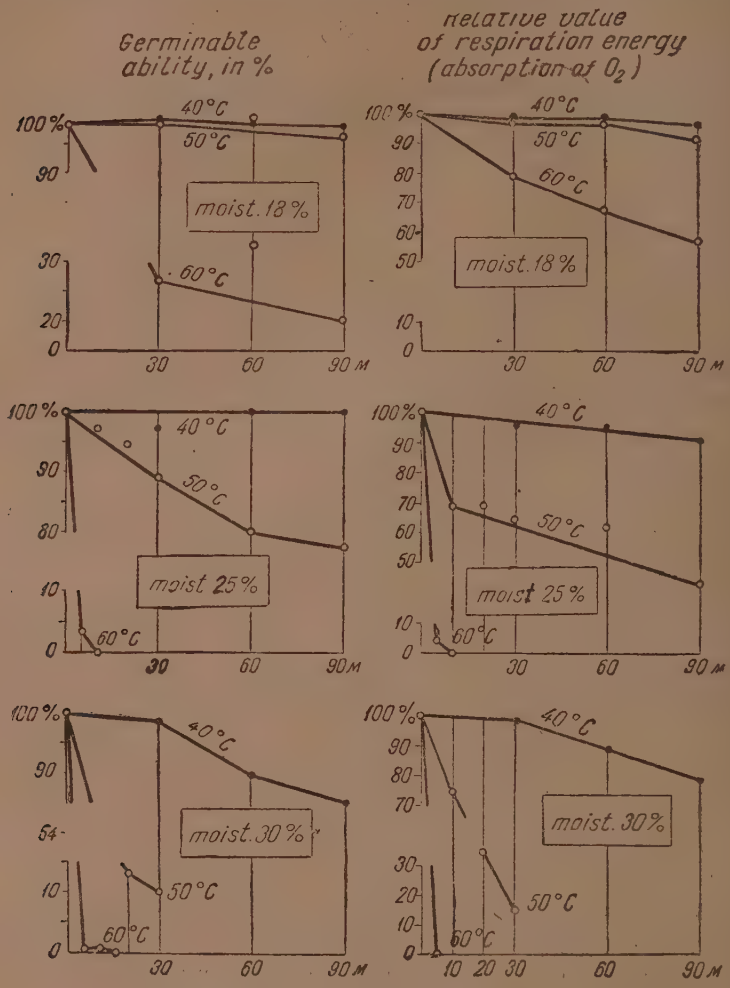
Moisture content of grain, %	Oxygen consumed		Carbon dioxide given off		CO_2/O_2	
	indiv. port.	mean	indiv. port.	mean	indiv. port.	mean
18	2.93 2.90	2.92	5.76 5.74	5.75	1.97 1.97	1.97
25	52.98 53.45	53.21	57.60 58.35	57.98	1.09 1.09	1.09
30	92.75 92.35	92.55	90.72 90.46	90.50	0.98 0.97	0.98

As may be seen from the value of the breathing energy, the life activity of grain is at its maximum within the moisture interval between 18—25 per cent. It is within this range (at 21 per cent) that after American writers ([3]) the amount of colloidally bound (non-congealing) water in grain stops to increase. In so far as the breathing intensity of the grain is directly related with the content in it of free (congealing) water, a sharper increase in the breathing energy within the interval referred to above is easily conceivable. In this juncture it should be mentioned that the ratio CO_2/O_2 varies along with the moisture content of the grain, which has already been observed at this Laboratory ([4]) and is accounted for by the respiration of meristematic tissues (embryo) prevailing at low moisture content of the grain ([5]).

The sensitivity of a grain to temperature corresponds to the degree of its life activity, which is manifest in the value of the germinating capacity of grain subjected to heating treatment. From the data of Tables 1 and 2, as well as from the run of the isothermal curves (see figure) it is obvious that the viability of ripe wheat grains is disturbed in full conformity with their moisture content and degree of their life activity.

A grain with a moisture content of 18 and 25 per cent easily withstands heating at 40 ° C during 1.5 hour. Beginning with 30 per cent this temperature affects the

grain's viability when applied during more than one hour. The grain withstands heating at 50° C without being injured only if its moisture content is below 18 per cent and the treatment lasts no more than one hour. With a 25 per cent moisture the grain shows the first signs of impaired viability after 10 minutes of treatment at 50° C. A grain whose moisture content is as high as 30 per cent does not withstand



Course of isotherms of the germination per cent (left row) and of the relative breathing intensity (right row) as influenced by moisture content of a grain when heated

this temperature even when it is applied during 10 minutes only. When heated up to 60° C the grain does invariably lose its viability, whatever low its moisture content and after the shortest treatment.

The existence of a relation between the grain viability and the degree of heating at various moisture content is fully confirmed by data on the variation of breathing intensity (Table 3 and figure).

If the isotherms illustrating the changes in the ratio of breathing energy are compared to those plotted for the changes in the rate of germination of a grain subjected to thermal treatment and dependent on its moisture content, the two methods for expressing the grain's viability are found to be in good agreement. And this is

Table 2

Germinating Power of Grain in per cent (as determined by Chigirev and Bronovizkaya)

Duration of treatment of grain, in min.	Temperature	Moisture of grain when heated		
		18%	25%	30%
0	Control	99.0	100	100
30	40°C	99.5	98.0	99.0
60	»	98.5	100	91.0
90	»	98.5	100	86.5
10	50°C	—	97.5	47.61
20	»	—	95.0	13.5
30	»	99.0	90.0	10.5
60	»	99.5	80.5	0
90	»	96.0	78.0	0
5	60°C	—	3.5	0.5
10	»	—	0	0.5
20	»	—	0	0
30	»	27.5	0	0
60	»	32.5	0	0
90	»	19.5	0	0

especially true if allowance be made for the unavoidable differences in the heat-resistance of individual seeds making part of the samples compared.

The results obtained, as well as some data available in literature (3) permit confidently to state that a fully ripe grain at the state of life-activity it possesses when its moisture content is above 21 per cent, starts losing its viability when

Table 3

O_2 Absorbed within one Hour at 25°C, in mm^3 per 1 g of abs. Dry Weight of Grain (determined by Ushakova)

Duration of treatment of grain, in min.	Temperature	Moisture of grain when heated		
		18%	25%	30%
0	Control	17.42	72.26	130.05
30	40°C	17.04	69.05	129.19
60	»	17.03	68.64	115.6
90	»	16.78	65.86	101.18
0	Control	17.37	71.40	130.05
10	50°C	—	50.05	97.27
20	»	—	49.52	44.73
30	»	16.91	46.67	18.36
60	»	16.83	44.03	—
90	»	15.78	30.49	—
0	Control	17.52	71.40	130.05
5	60°C	—	2.59	0
10	»	—	0	0
30	»	13.90	0	—
60	»	11.74	0	—
90	»	10.01	0	—

heated at 50° C, while it proves well to resist to a temperature of 40° C if heated during 30 minutes. According to its heat-resistance, a grain of such a moisture content does not differ materially from any vegetative part of the plant (6). A. Kursanov and his co-workers (7) observed in leaves of cyclamen at a temperature above 40° C to take place a sharp drop of fermentative synthesis (of saccharose), which they referred to a decay of cellular structure.

A grain with an 18 per cent moisture content withstands safely a treatment at 40° and even 50° C, provided it lasts no more than one hour.

On the ground of the experiments described we arrive at a conclusion that a fully ripe grain when damp differs but little as to its susceptibility to heating from newly stored grain. According to Kretovich, the temperature in an exsiccator loaded with freshly cropped grain should not exceed 45° C on the average ([8]).

When drying such ripe grain under practical conditions, allowance should be made for a possible loss or reduction of germinating power, caused by high temperature and lengthy heating, as it is usually made in the case of a freshly harvested grain.

Concluding the discussion of the data obtained it should be pointed out that the drying of a damp grain, when followed by a reduction of its moisture content to the original level, goes sharply to increase its breathing intensity. This may clearly be seen when comparing our data on oxygen absorption previous to drying of a wetted grain (Table 1) with those after air-drying (without heating), followed by a reduction of the moisture content to its original value (Table 3, controls). The phenomenon may be put down to an increased fermentative activity, serving as a catalyst for the formation of simple carbohydrates from polysaccharides in the course of dehydration and oxidation. Practioners should take it as a warning and never allow grain to be repeatedly wetted on the assumption that when dried in due time, it will be prevented from being affected by micro-organisms.

Institute of Biochemistry.
Academy of Sciences of the USSR.

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MICROBIOLOGY

VOLATILES EVOLVED BY FLOWERS AND LEAVES AS A SOURCE OF NUTRIMENT FOR MICRO-ORGANISMS

By N. G. CHOLODNY, Member of the Academy of Sciences of the Ukrainian SSR

In my previous note (1) I advanced the assumption that those volatile organic compounds «which in minute amounts are evolved by flowers...., being in some cases responsible for their fragrance, do not always dissipate without traces. Under favourable conditions they may also be absorbed and assimilated by other organisms».

In order to verify this statement I carried out during the summer 1943 a series of experiments at the Kirovakan Division of the Botanical Gardens of the Armenian Branch of the Academy of Sciences of the USSR.

The method applied differed from that described earlier (1, 2) only in some details. As receivers for the plants use was made of broad-mouthed glass jars of half a litre capacity, fixed in a horizontal position. Instead of covering-glasses, soil dust was spread over object-glasses which were horizontally arranged in the jars in such a way that their narrow edges be supported by the side walls of the receivers. The dusted surface was, as a rule, turned upwards. The rims of the receiver's mouth were usually smeared with vaseline. The jars were covered with square pieces of thin plate-glass. To make the air inside the receivers humid, a little warm water was poured in each of them.

For the experiments such plants were mostly chosen which have small flowers clustered into compact inflorescences. One or several such inflorescences, bound into a small bunch, were introduced into the jar and fixed at its bottom with the help of a second object glass, uncovered with soil dust. There was always left free space between the two glasses, in order to prevent the preparation from being soiled or from an occasional contact with the petals or some other parts of the plant.

The air exchange within the vessel was secured by leaving a narrow slit between the glass-cover and the rim of the mouth of the vessel. Because of the chlorophyll present in the green vegetative leaves of the pedicles and in other parts of the plant taken for experiment, the oxygen given off by them, together with the air oxygen supplied from without, through the slit, guaranteed for a more or less normal respiration of the parts devoid of chlorophyll. The receivers were placed in scattered light, upon the window-sill of the laboratory and were thus subjected to natural fluctuations of the room temperature.

In spite of all the precautions taken, not all the objects tested did equally withstand a prolonged stay (up to 2 days) in the humid air of the receiver. In some of them after the end of the experiment the flowers were found to be absolutely fresh and to have even preserved their original fragrance. In other, more susceptible ones, part of the blossoms of the inflorescence became brown by the end of the experiment, and mould appeared upon their surface. The most resistant proved the inflorescences of *Cirsium ciliatum*, *Carduus hamulosus*, *Achillea millefolium*, *Trifolium pratense*, *Silene compacta*, and of some others.

For the majority of the tests soil was taken from a hot-house, which had been added horse-dung 15 months previous to sampling and starting the tests. The hot-house soil which abounded in various micro-organisms proved the most appropriate for these experiments.

Let us sum up here the most important results of the experiments performed without dwelling upon the details.

It has been found that the organic substances evolved into the air by the flowers of all the plants tested may serve as a good source of nutriment for various micro-organisms. This is clearly evidenced by a rather abundant development of bacteria, fungi and actinomycetes upon the preparations of soil dust, which considerably exceeds, as a rule, the growth of the same microbial organisms upon the control preparations. In some of the cases, for example, in our experiments with clover and yarrow, large areas of the glass were found to be covered with important colonies of bacteria that could readily be detected by an unaided eye. As to the intensity of growth, these preparations did in the majority of cases considerably exceed anything that has ever been observed in experiments with germinating seeds (1).

A condition necessary for the success of these experiments is a perfect state of the flowers introduced into the chambers. If the flowers taken for the experiment are not quite open yet, they may often fail to open at all in a humid chamber, and the experiment will then prove a failure. On the other hand, such flowers as have already completed their life-cycle and started withering, give no due effect either. The evolution by flowers of volatile organic substances seems to fall within a definite, rather brief period of their development.

No less important are also temperature, light and humidity conditions. The window near which the plant receivers were placed in my experiments, opened to the South. The plants were sheltered from direct sun rays by a screen prepared with oil-paper; at cloudless days they received, however, rather bright light during several hours. According to my observations, such an illumination was beneficial for the evolving of organic volatiles. During cloudy, cold days the production of the latter seemed to be abated. However, the results might prove different in case the tests were run with such flowers as open by night.

The high humidity content of the air of the receivers was necessary, of course, for a successful development of micro-organisms only. The physiological state of the flowers was in most of the cases unfavourably affected by it; it could, however, not possibly be avoided.

Another important result of the experiments here described bears upon the character of the microflora that developed on the preparations of the soil dust. When use was made of the very same soil samples, the microscopical picture offered by the preparations treated with volatiles evolved by various plant species used to differ, sometimes rather considerably. Thus, *e. g.*, the emanation from the flowers of clover and millifolium induced an opulent growth of various bacteria which formed over the glass large colonies coloured more or less intensely*. The cells in these colonies were in most cases tightly pressed together, occasionally almost coalescent into a uniform film, the boundaries between individual cells being scarcely discernible. The substances evolved by the flowers of *Carduus hamulosus* and *Cirsium ciliatum* promoted the multiplication of mucilagenous bacteria whose mass colonies consist mainly of feebly staining mucous. Bacterial cells of a more intense colour were found to be inserted in this mucous, being often set apart at a considerable distance.

Sedum oppositifolium whose flowers exhale but a very faint odour, caused an abundant multiplication of actinomycetes. The same phenomenon was observed with *Solidago canadensis* whose flowers have a strong odour of honey. In some cases an intense growth of fungi could be observed.

In those cases when the microflora on a given preparation was found mainly to consist of bacteria, a closer examination of the bacterial flora on preparations

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* The preparations were stained with gentian-violet.

from experiments made with plants from different families revealed that the composition of the microflora was different.

All these facts may be explained only by assuming that flowers of different plants give off into the surrounding air organic compounds which differ considerably as to their chemical nature*.

Flowers of various species, endowed with a similar honey-like odour (clover, *Carduus*, *Solidago canadensis*, *etc.*) seem nevertheless to emanate different substances, for they induce development of different microfloras. We have already mentioned the difference between the microflora induced by clover and by *Carduus*. The effect of *Solidago canadensis* is characterized by the prevalence of actinomycetes with numerous large spores in the shape of bent rods, whereas bacteria fail to develop on preparations exposed to the emanation of this plant. In this case the microflora is specifically uniform to such an extent that one cannot help thinking of an «elective effect» of the volatiles evolved by the plant in question.

In my previous note (1) it has been pointed out that experiments with green leaves severed from the plants yielded a negative effect. New experiments with leaves, carried out by me at Kirovakan, showed that in some cases, *viz.* in plants whose leaves accumulate appreciable amounts of products of secondary synthesis, these products are sometimes able appreciably to increase the growth of microorganisms on preparations of soil dust. Especially illustrative was the result of the experiment carried out with tips of pine-twigs covered with dense needles. I observed here an intense development of bacteria apparently belonging mainly to the genus *Corynebacterium*. In this connexion it should be pointed out that according to the data of our earlier experiments, the vapour of pine is a good source for aerial nutriment for some fungi.

On a preparation placed in a chamber with several twigs of *Teucrium polium* (fam. *Labiatae*) which were left only their green leaves, I observed an abundant growth of actinomycetes of the same type as induced by the volatile emanations of flowers of *Solidago canadensis* (fam. *Compositae*).

Curious enough, in the experiment with flowering shoots of *Teucrium polium* among the microflora there were prevalent various bacteria which formed at places considerable colonies staining intensely, while actinomycetes made their appearance but occasionally. This goes undoubtedly to confirm that the volatiles evolved by flowers and leaves of *Teucrium polium* differ as to their chemical nature, the organic substances emanated by the flowers being of a higher nutrient value.

In the experiments with leaves of *Artemisia absinthium* and *Mentha longifolia* there was no increase in the development of microflora; on the contrary, it was even found to be suppressed appreciably, so that the microflora of the respective preparations was much poorer than that of the controls which received no additional nutriment from the air.

In chambers that contained vapour of lavenda and anise oils, the preparations of soil dust remained sterile. It should be called to mind in this place that the bactericidal or at least growth inhibiting effect of the volatile emanation of onion and of some plants containing volatile oils has already been reported in literature.

Conclusions

1. Flowers of various plants during a definite period of their development give off into the air complex volatile organic compounds which offer a good source of nutriment for many micro-organisms, chiefly bacteria and, to a lesser degree, to actinomycetes and fungi.

2. The chemical nature of these volatile compounds varies as to the plant. The microflora on preparations of soil dust treated with substances evolved by flowers of different plants, proves therefore highly variable, even if the same soil sample is being applied.

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* The taxonomically related *Carduus hamulosus* and *Cirsium ciliatum* seem to evolve identical substances or substances that are much similar as to their chemical nature: in both cases the preparations of soil dust offered the same picture.

3. The flowers of different plant species though endowed with a similar fragrance, induce the development of a microflora differing as to its composition; this should be taken to mean that the volatile compounds they emit differ as to their chemical nature, in spite of the likeness of their odour.

4. The volatile organic compounds evolved by leaves rich in products of secondary synthesis do also sometimes enhance the growth of microbes on preparations of soil dust (pine needles); in other cases their effect is to suppress this growth (leaves of *Artemisia absinthium*, *Mentha longifolia*).

Armenian Branch
of the Academy of Sciences of the USSR.

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PLANT PHYSIOLOGY

NITROGENOUS FOOD AS A FACTOR INCREASING THE RATE OF FLOWERING AND FRUITING IN PLANTS

By M. Ch. ČAJLACHJAN

(Communicated by A. N. Bach, Member of the Academy, 2.VIII.1943)

According to an old tradition, it is generally believed that a food rich in nitrogen impedes the plants' passing in the phase of flowering and ripening, whereas phosphates do, on the contrary, stimulate their ripening. In our work carried out in 1940 at this Institute I succeeded in establishing that different plants respond in a different way to their mineral diet (1).

Oats that by the kind of their photoperiodic reaction belong to the group of long-day plants, under the conditions of a natural long day in Moscow, started flowering the sooner, the less elements of mineral food they were supplied. Unlike them, millet plants that belong to the group of short-day species passed to the flowering phase and fruiting the sooner, the greater the total amount of mineral compound was contained in the nutrient substratum.

At this juncture, two problems were subjected by me to experimental analysis: 1) to what extent the opposed reactions for mineral food recorded for the two species referred to above may be extended to the rest of plants, and 2) which of the mineral elements of the total nutrient mixture produces the decisive effect upon the plants' development.

In order to answer the first question I undertook in 1941 at this Institute experiments with several agricultural plant species, different as to the nature of their photoperiodic reaction. These were: the oat variety «Pobeda» (*Avena sativa*), blue lupine (*Lupinus angustifolius*), lettuce (*Lactuca sativa*), all of which are long-day plants; the millet variety «West China» (*Panicum miliaceum*), the soya variety «Illini» (*Soja hispida*), southern hemp (*Cannabis sativa*), which are short-day plants, and buckwheat (*Fagopyrum sativum*), a plant neutral to daylength.

The main purpose of the experiments was to grow plants in media differing as to the total content of mineral elements, and under different light conditions. The scheme of the experiments was, correspondingly, the following: 1) the plants were grown in sand and received complete Prianishnikov's nutrient mixture ; 2) the plants received a quarter of this mixture; 3) the plants were given no nutrient substances at all and were grown in glowed and washed sand.

Moreover, one half of the plants of each of the experimental sets were kept: 1) under conditions of a natural long day in Moscow (L) and 2) under conditions of a short 10 hour-day (S). In order that the latter condition be satisfied, the plants were entered since 6 p. m. into a dark photoperiodic chamber where they were kept until 8 a. m.

The experiments were carried on in glass vessels containing 4 kg of sand each; both water-soluble and dry fertilizers were given when filling the vessels; the

moisture was continuously kept at 70 per cent to the total moisture capacity of the sand. Every set had two vessels.

The seeds were planted on 21—29th of May: hemp and lupine, on May 21; oat, lettuce and buckwheat, on May 22; millet, on May 23; soya, on May 29. A corresponding light-regime was observed since the appearance of shoots and until the end of the experiments. Throughout the experiment the plants were observed phenologically, the dynamics of their growth studied and observations connected herewith carried on. By the end of the experiments, the dry weight of the aboveground parts was accurately recorded; in most of the cases the same was done for the roots as well, after these were thoroughly washed-off and dried. The most essential data bearing on the growth of the plant, accumulation of dry mass and on the rate of growth under varying conditions of mineral food and under a favourable light-regime are summarized in Table 1. The data given for millet and oat refer to the formation of culms, those for lettuce, to budding, for the rest of plants, to flowering.

Table 1

Growth and Development of Plants under Favourable Light Conditions as Affected by Mineral Diet

Plant	Light conditions	Height of plant by the end of exper. in cm			Dry weight of aboveground parts of 1 plant in g			Culm formation or flowering			Test complete on
		0	¼	1	0	¼	1	0	¼	1	
Oat «Pobeda» . .	L	19	55	63	0.10	1.14	3.20	6.VII	10.VII	9.VII	16.VIII
Blue lupine . . .	L	18	32	47	0.27	0.71	3.00	abs.	31.VII	18.VII	1.IX
Lettuce	L	2	22	42	0.01	1.09	2.42	abs.	17.VII	23.VII	16.VIII
Millet «West China» . . .	S	3	17	30	0.02	0.39	3.18	14.VII	6.VII	4.VII	16.VIII
Soya «Illini» . .	S	9	13	—	0.32	0.53	—	14.VII	14.VII	14.VII	8.VIII
Southern hemp .	S	5	32	32	0.03	0.21	1.06	14.VII	7.VII	9.VII	1.IX
Buckwheat . . .	L	11	—	47	0.03	—	2.42	25.VI	—	23.VI	9.VIII
Buckwheat . . .	S	10	—	25	0.03	—	0.83	25.VI	—	24.VI	9.VIII

Analysing the data tabulated bearing on the height and dry weight of the plants, it can easily be seen that the increase in the amount of mineral elements in the nutrient mixture is accompanied by a regular increase in the plants' growth and in the accumulation by them of dry mass.

Of paramount interest are data referring to the developmental rate of the plants. According to them, the plants may clearly be subdivided into three groups:

Group I. Such as start flowering the sooner, the less elements of mineral food they have been given (oat «Pobeda»).

Group II. Plants that start flowering the sooner, the more elements of mineral food they have been given (millet «West China» and blue lupine).

Group III. Plants that start flowering all at one, irrespective of the mineral food given (buckwheat, soya «Illini»).

Less definite results were obtained from the experiments on lettuce and southern hemp; however, a trend towards a higher rate of development in the case of a more copious mineral food is also observable. No tubercles upon the roots of leguminous plants were observed in any of the cases.

All these data go to confirm that the different and contradictory response in flower formation to the various mineral food conditions, as previously traced for oats and millet alone, may be extended to other vegetable species.

In order to solve the second problem, along with the first set of experiments another set was carried on, this time involving oat and millet plants. These experiments showed that the differences that had been observed to accompany changes

in the whole complex of the elements of a nutrient solution are largely due to alterations in the content of the nitrogen compounds.

During the same year I carried out experiments on the influence of nitrogenous food upon the development of plants. Two more plants were taken for experiment, *viz. Perilla nankinensis* and *Sinapis alba*, as well as lettuce and southern hemp. The experiments were run in two sets: 1) Prianishnikov's normal nutrient solution containing only $^1/_4$ of nitrogen, and 2) normal solution containing a double amount of nitrogen (*2N*).

The experiments were carried out in large battery glasses, containing 0.7 kg of sand each, the moisture of sand being 70 per cent to total moisture capacity.

Fig. 1

Mustard, hemp and lettuce were sown directly in the glasses on May 21—22; perilla was sown on May 5 into boxes containing soil, and the plantlets replanted on June 4 into glasses. After the sprouts appeared, half of the plants of each set were exposed to a short 10-hour day (S), another half left under natural day conditions (L). There were four glasses in every set.

The experiments with mustard and hemp were complete by July 14; with perilla, by August 28; and with lettuce, by September 10.

The results obtained bore out clearly enough an increase in both the growth and dry weight of the plants given additional nitrogenous food (Table 2).

Under conditions of a long summer day perilla and hemp did not enter the phase of reproductive development, while mustard and lettuce failed to pass to reproductive development under conditions of a short day.

Under light conditions beneficial for the plants' development the following picture was observed: 1) Mustard began to flower much sooner if given food poor in nitrogen ($^1/_4$ *N*). When given additional nitrogen (2 *N*) it failed to flower, and until the end of the experiment only a few isolated buds have been formed. 2) Perilla and lettuce responded in an opposite way: they set in flowering much sooner when given additional nitrogen diet. 3) Hemp plants given food rich in nitrogen started flowering about the same time as those given a diet poor in nitrogen (Figs. 1 and 2).

Table 2

Development of Plants Grown under Different Light Conditions, as Affected by Nitrogenous Food

Nitrogenous food	Mustard (flowering)		Lettuce (budding)		Perilla (flowering)		Hemp (budding)	
	L	S	L	S	L	S	L	S
Nutrient solution+$^1/_4$ *N*	22.VI	Abs.	30.VII	—	Abs.	29.VII	Abs.	24.VI
Nutrient solution+2 *N*	Abs.	Abs.	14.VII	—	Abs.	16.VII	Abs.	26.VI

Fig. 1 (photograph taken on June 27) shows mustard plants that were grown under conditions of a natural long day upon full nutrient solution except for ammonium nitrate. Vessels Nos. 11 and 12 were added $^1/_4$ of the normal amount of this

Fig. 2

nitrogenous compound. The plants rapidly went through the phases of stalking, flowering and maturation, and began shedding their leaves. Vessels Nos. 43 and 44 were added two rations of ammonium nitrate: the plants failed to pass the phase of stalking and are making vigorous vegetative growth.

Fig. 2 shows perilla plants grown under conditions of short 10-hour-day upon full nutrient solution, except for the ratio of ammonium nitrate. Vessels Nos. 37 and 51 were added two normal portions of this compound. The plants went through the phase of budding and flowering and are at the phase of ripening. Vessels Nos. 5 and 22 were added $^1/_4$ of the normal amount of ammonium nitrate. The plants failed to pass to flowering and still are at the phase of budding.

Thus, a diet rich in nitrogen, stimulating the accumulation of dry mass and the growth of all the plants, inhibits flowering and fruiting in some of them (mustard and oat), speeds up flowering and fruiting of others (perilla, millet, lupine, lettuce), and has no influence whatever upon the rate of these processes in a third group of plants, *viz.* in buckwheat, soya and hemp. Hence the following conclusion: contrary to the generally adopted idea that an increase of a nutrient substratum in nitrates prevents all plants from entering into the phase of flowering and matura-

tion, there is a number of plants for which nitrogenous food should be considered as a factor stimulating them to form flowers and fruit.

Now the question has to be answered as to the relation between the periodic reaction and the reaction to nitrogenous food in the very same plants.

When the experiments here described had already been complete, I became acquainted with the paper by Denffer ([2]), containing a description of his experiments on water-cultures upon Pfeffer's nutrient solution minus nitrogen. The effect of nitrogen withdrawal was to accelerate the development of the long-day plants: summer wheat, barley and *Iberis amara*, and to inhibit the development of the short-day plants: *Tinantia fugax*, *Setaria italica*, *Kalanchoe* Blossfeld and *Chrysanthemum* Mepho. This makes the writer conclude that an opposite response of the plant to nitrogen withdrawal is connected with the kind of its photoperiodic reaction. In my experiments, rich nitrogenous diet was found to stimulate the growth not of short-day plants alone, such as perilla and millet, but also of long-day plants, *viz.* of lupine and lettuce. At the same time, however, it failed to affect the development not only of plants neutral as to the their photoperiodic reaction, but also of short-day plants, such as soya and hemp.

A simultaneous response of the plant to light conditions and to conditions of their mineral, in particular, nitrogenous food, seems to be a more complicated phenomenon which requires further experimental analysis.

K. A. Timiriazev Institute of Plant Physiology.
Academy of Sciences of the USSR.

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ZOOLOGY

DETERMINATION OF NATURAL SPECIFIC GRAVITY IN FISH

By A. P. ANDRIASHEV

(Communicated by E. N. Pavlovsky, Member of the Academy, 19.IV.1943)

The relation between the fishes and the bottom of the basin they inhabit varies greatly according to the species.

Most closely connected with the bottom are burrowing species (in the Black Sea these are *Uranoscopus*, *Trachinus*, *Pleuronectes* and others). There are many species that dwell at the bottom being very sluggish (*Lophius*, *Scorpaena*, *Bothus*, *Benthophilus*, *Lepadogaster* and others). Some, which are also typical bottom dwellers, are by far more active (most species of the genus *Gobius*, *Blennius*, *Trigla*, *Raja*, *Trygon** and others) and may even leave the bottom for a longer time (*Mullus*, *Gaidropsarus*, *Zostericola*); some species always keep close to the bottom, hiding in crevices of rocks and among sea weeds, but most of the time are not in contact with the ground (*Serranus*, *Crenilabrus*, *Ctenolabrus*, *Labrus*, *Chromis* and others). Many fishes—good swimmers—though belonging to bottom feeding species, as a rule, never rest on the bottom** (*Odontogadus*, *Sciaena*, *Umbrina*, *Sargus*, *Charax*, *Squalus*, *Acipenser*, *Mugil* and many others).

According to the degree to which their main life processes are related to the bottom, these species are ecologically defined as «bottom species», «demersal species», «bottom-feeders» and so on, though, however, these terms lack precision.

In this connexion the natural specific gravity of fishes seems to be of some interest, since a certain relation is likely to exist between the specific gravity and the activity of fishes: on the other hand, it is known that the closer a fish is connected with the bottom, the less it is active.

The literary data available are not sufficient to answer this question. Thus, Shoulejkin and his co-workers ([1], [2]) in their investigations on the hydrodynamical properties of fishes assumed the density of fishes to be identical with that of the sea water; this leads to a difference beginning with the second decimal point.

Stas ([3]) who determined the specific gravity in 19 species of Black Sea fishes (with the help of a metallic pycnometer and volumetrically) obtained but approximate values with a precision up to 0.01. The determination of natural specific gravity being out of the scope of his work, Stas was piercing the air bladder of the fishes, thus obtaining a levelled scale of specific gravities ranging from 1.04 to 1.08.

Schmalhausen ([4]), without mentioning the method used, gives a series of values of the specific weight for Mediterranean fishes, which in some cases are obviously

* To this group belong also *Ophidion*, *Solea* and *Ammodytes*, fairly active fishes, though of burrowing habit.

** Except when hibernating in pits, as do *Acipenseridae* and some other fishes.

inaccurate. The data by Tester ([5]) refer to herring only, and besides, because of the method employed, they fail to give an idea of the natural specific gravity.

The specific gravity in fishes varies within a very narrow range for different species (in Black Sea fishes roughly from 1.01 to 1.09); thus, in order to obtain a graduated scale necessary for comparisons of species, the determinations of specific gravity should be performed with an utmost precision, *viz.* no less than to 0.001—0.002.

At the Sevastopol Biological Station we have worked out a method for determining precise natural specific gravity of fish. Determinations were made gravimetrically, according to the formula $d = \frac{Pk}{P - P_1}$ where P is the weight of fish in the air; P_1, the weight of fish in the water; k, the density of water, in which the fish has been weighed. A strict observance of the procedure (pre-treatment of the fish, procedure of killing, uniform drying, accuracy and duration of weighing, removal of air bubbles from gill- and mouth cavity, and so on) enabled us to determine the specific gravity with a precision up to ± 0.001*.

Special attention was given to the method of killing prior to weighing. Twenty four hours before the determination of specific gravity the fish was transferred to a separate aquarium with a perforated veneer screen lowered on a special support and fixed 10—15 cm beneath the water level.

The fish, kept during 24 hours under the fixation screen, was freed from excrements (especially important in mollusk-eating fishes, such as *Gobius melanostomus*) and, above all, completely isolated from atmospheric air which strongly affects the results of water-weighing.

The fishes were killed under the fixation screen (by introducing formalin), so that no air could be swallowed before weighing, as is the case when fishes are caught in the usual way.

Over 100 determinations of specific gravity have been made on the Sevastopol Biological Station and at its expedition base at the bay Yarylgash (Karkinitsky gulf); the determinations refer to twenty species of inshore fishes, which fall into two large groups:

1. Fishes with Air-Bladders. We investigated species of the genera: *Trachurus*, *Smaris*, *Odontogadus*, *Gaidropsarus*, *Serranus*, *Crenilabrus*, *Ctenolabrus*, *Zostericola* and others. The natural specific gravity of this group is not constant, varying within a certain range, usually approaching the specific gravity of sea-water or slightly exceeding it. Representatives of this group showed variations ranging from 1.012 to 1.021.

No pronounced specific distinctions could be observed, though the tendency to keep to the bottom in the species of this group varies greatly.

2. Fishes without Air-Bladders. This group is especially interesting for the problem of relation between the specific gravity and the degree of «bottom tendency». The specific gravity of this group is fairly constant, differing in species with different ecological characteristics, but showing but slight variations within a species **; thus, for instance, in *Scorpaena porcus* variations of specific gravity usually do not exceed 1.077—1.079 (determinations made for 10 specimens).

The highest specific gravity 1.085 was recorded for *Uranoscopus scaber*, the most sluggish representative of the Black Sea inshore fish-fauna; this fish lurks for its prey, being completely buried in the sand. *Trachinus draco*, also a burrowing fish, but a far more lively one, has a specific gravity 1.080.

Among non-burrowing species *Scorpaena porcus* is the most closely connected with the bottom; it remains mostly immobile on the ground between stones and algae; its specific gravity, though high enough, is lower than that of *Trachinus draco*, averaging 1.078.

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* Such an accuracy finds itself justified when calculating the absolute and relative errors of the initial quantities.

** Determinatons were made during the spring-summer period, so that seasonal changes of specific gravity could not be accounted for.

Much more active are the ground gobies: they do not only lie in wait for their prey, but actively search their food on the ground. The specific gravity of the species investigated (*Gobius melanostomus*, *G. ratan*, *G. fluviatilis*) varied from 1.070 to 1.078.

The lowest specific gravity has been found in *Mullus barbatus ponticus*, a swarming fish, migrating over a great extent, which feeds only on the bottom. Its mean specific gravity is 1.061.

Unfortunately, no determinations of specific gravity could be made for typical pelagic fishes without air bladder (*Scomber*, *Sarda*) which must have a still greater buoyancy. On the other hand, many marine species seem to have higher specific gravities than *Uranoscopus*, as, for instance, the armoured bottom species of the fam. *Agonidae*.

The series listed above may be supplemented on the ground of literary data [3]. Thus, *Solea nasuta*, as active as the species of the genus *Gobius*, has a specific gravity of 1.07; the still more lively *Blennius*, of 1.06, while the free-swimming demersal fishes *Acipenser stellatus* and *Squalus acanthias* have considerably lower specific gravities, 1.05 and 1.04 respectively.

Though we do not feel authorized on the basis of these preliminary data to assert that variations of specific gravity are directly proportional to the degree of the «bottom tendency» in fishes, the values obtained go well to support this assumption. In this respect the very interesting data of hydrophysicists [1—3] on the coefficient of full displacement (Stas) and characteristical coefficient of sea worthiness (Shoulejkin) offer no satisfactory results, being separated from the living object, its morphology and biology, and concerned mainly with the precisely measurable values of volume, cross-section, streamline of the body, its hydrodynamical properties, and so on.

It should be noted that the system according to which the fishes are classed in the work of Stas [3] «from the swiftest swimmers to those resting on the bottom» is by no means conform to reality. Thus, *Scorpaena* is listed alongside of *Mullus* and *Odontogadus* (*Gadus euxinus*) and *Squatus* next to *Blennius* and *Uranoscopus*, whereas such an excellent swimmer as *Acipenser stellatus* is put at the end of the table with *Solea*.

Determinations of specific gravity of fishes are not only of a theoretical, but of a practical interest as well as evidenced by the work of Tester [5], who established homotypical seasonal variations of fatness and specific gravity in the herring. As a result it was found possible to adapt simple determinations of specific gravity instead of the cumbersome quantitative determinations of fatness.

Sevastopol Biological Station.
Academy of Sciences of the USSR.

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EXPERIMENTAL MORPHOLOGY

ON THE TYPE OF POSTEMBRYONIC SKELETAL GROWTH IN *OVIS ARIES* L.

By V. J. BROVAR

(Communicated by I. I. Schmalhausen, Member of the Academy, I.IX. 1943)

I. An attempt to determine on ground of data by Chirvinsky ([5]) the mode of the sheep growth by weight revealed that the axial part of the skeleton shows no expected regular decrease in growth intensity from one division to another (see table, line *Aa*: *An*). An analogous result was obtained when recalculating data by Hammond ([3]) (see table, line *Ba*: *Bn*).

The irregular variation in the intensities referring in both cases to females is at random, though no similar one; besides, it differs in this respect from the irregularity of the respective relations in the males Nos. 41 and 52, as described by Chirvinsky, and Nos. XV and XX, by Hammond (recalculations omitted).

All this seemed anything but probable and made me have recourse to new material. The one available proved, however, to consist of a newborn Sheviot male, far from being perfect, and an adult Kent female, 4, 5-year-old; both perished from an acute disease.

A recalculation of the data obtained gives the axial gradient sought for (see table, line *Ca*: *Cn*). It is obtained also in the case if we refer Chirvinsky's and Hammond's data for adult sheep both to our adult individual and to the newborn, as described by Chirvinsky.

The system of the postembryonic intensities of growth by weight, as observed in the skeleton of *Ovis aries*, can thus be characterized in the following way: 1) the skeleton as a whole grows less intensely than the live weight; 2) the axial skeleton grows more intensely than the peripheral one (extremities and their girdle); 3) the intensities of growth in the axial skeleton are distributed over a gradient with a centre in the sacrum; 4) the peripheral skeleton has also an intensity gradient with its centre at the girdle, as has already been found by J. S. Huxley (1931).

Besides these, there exist some other regularities which are of no importance here. The males display, of course, all the regularities listed which are common to the genus *Ovis aries* L. as a whole.

II. A similar system of intensities is already known for the growth of the skeleton in the rest of mammals ([2]), and is therefore of no particular interest by itself. It is another point that deserves our attention, *viz.* the differences between the relative weights of the animals and the surprisingly high variations of their growth coefficients.

One naturally feels tempted to suspect here the existence of some intraspecific variations of the system of intensities established, reflecting the peculiarities of the development of a given species, at that. Any attempt to clear this important question is so essential that it is impossible to relinquish it, however imperfect the material available.

Several considerations make us adopt as a working fiction the identity of the initial form in all three cases. In this way those necessary changes in an intensity system are most clearly revealed, in the case of which one newborn may give rise to three different definitive forms.

When referring the weight of each skeleton to that of the newborn *Cn* which differs from the rest as to sex and breed, and comparing the coefficients of growth (see table), an important conclusion can be made: all coefficients of the sheep *Aa* as compared to those of the other three, invariably show extreme values, being either minimum or maximum ones. This should be interpreted as a sharp distinction of the intensity system of sheep *Aa* from that of the other two sheep.

Absolute Weight of Skeleton Parts of *Ovis aries* L. (in g) According to and Indices of Relative Intensities of Postembryonic Growth

Parts of skeleton / Nos. and sex	*Calvarium*	Lower jaw	Skull	Cervical portion	Dorsal portion	Lumbar portion	Sacral portion	Caudal portion	Spinum column	Ribs	*Sternum*	Whole axial skeleton
1	2	3	4	5	6	7	8	9	10	11	12	13
I. Absolute Weight (in g) of												
An (♀♂)	—	—	86.9	19.84	18.32	13.30	4.90		56.36	17.38	4.69	165.33
Bn (♀)	157.7	81.1	188.8	85	93.4	58.6	13	6.4	256.4	146.8		592.0
Cn (♂)	89	23	112	38	35	22	7	3	105	48	8	273
Aa (♀♀)	—	—	577	208.5	195.05	137.95	61.1		611	316.44	63.5	1567.94
Ba (♀)	753	280	1033	426	427	359	117	24	1353	911	148	3445
Ca (♀)	794	253	1047	379	373	326	97	25	1199	738	129	3115
II. Twice Relative Coefficients (*Q*)												
Aa:*An*	—	—	0.83	1.36	1.33	1.30	1.56		1.36	2.28	1.69	1.19
Ba:*Bn*	0.92	1.73	1.05	0.96	0.88	1.18	1.73	0.72	1.01	1.19		1.12
Ca:*Cn*	0.91	1.13	0.96	1.02	1.09	1.51	1.53 (1.29)	0.85	1.17	1.58	1.65	1.17
Aa:*Cn*	—	—	0.99	1.06	1.15	1.21	1.18		1.03	1.27	1.53	1.11
Ba:*Cn*	0.76	1.10	0.83	1.01	1.10	1.47	1.51 (1.41)	0.72	1.16	1.71	1.67	1.14
III. Deviations of Relative Coefficients of Growth in Sheep *Aa*												
Aa—*Ba*	—	—	+0.16	+0.05	+0.05	—0.26	(—0.23)		—0.13	—0.44	—0.14	—0.0
Aa—*Ca*	—	—	+0.03	+0.04	+0.06	—0.30	(—0.14)		—0.14	—0.31	—0.12	—0.0

Notes: 1. Letter *A* denotes animals described by Chirvinsky (mean data); *B*, those by Hammond.
2. The figures contained in the columns headed by «whole» are conventional; Chirvinsky did not the weight of the bones omitted in the table is as follows (in g): *hyoideum*, 1 and 9; *carpus*, 5 and 20.
3. The weight of the spine column for the sheep *Aa* has not been obtained by summation, but adop-
4. From indirect considerations and according to calculations, one may conclude that by the name *i. e.* the two *ossa innominata*, but without the *os sacrum*. The weights of those bones in the table are
5. By the «skull» Chirvinsky most probably understood the *calvarium* alone. This correction
6. The live weights of *An* and *Aa* are given approximately.

It becomes still more evident if deviations are considered: these are always preceded by the same signs, being often near to one another by their absolute magnitudes, as well.

Thus, in spite of the fact that all the three sheeps show an absolutely identical type of growth, one of them (*Aa*) stands apart from the rest: the growth intensity of its axial skeleton is reduced, that of the peripheral being correspondingly increased. Within the two divisions, however, not all parts are altered univocally. Thus, in the axial skeleton it is the intensity of growth of the skull, the cervical and thoracic divisions that are increased, while the peripheral skeleton occasionally shows reduced growth intensity, *viz.* in both girdles.

Per se, these variations are so diversifield and so feebly expressed that they may even suggest the erroneous idea that the extreme value of the coefficients points to a difference of intensities increased in *Aa*. They should therefore be analysed not independently, but as variations in the type of growth, which is similar for all the three types of sheep. Their real general meaning will then easily be made clear.

Namely: the growth intensities in the system of the sheep *Aa* are maximum ones as compared to those of the sheep *Ba* and *Ca* in those cases where all the sheep invariably show growth intensities minimum for their respective types. And inver-

sely, they are minimum in *Aa* there where the intensities are maximum in the type. This should be taken to mean that the peculiarity common to the system of growth intensities in sheep *Aa* consists in a relative decrease of high intensities, and in an increase of the low ones.

Hence a direct conclusion may be derived:

1) The difference between the growth of the axial and the peripheral skeletons, which is the most important for the system of the type (type criterion), is leveled out because of a decrease in the intensity of the former and a relative increase of the latter. Thus, the two intensities tend to equality, which means an approach to a different type of growth (2).

Data by Chirvinsky (1909), Hammond (1932) and the Present Author by Weight of Those Parts, as Deduced from these Data

Scapula	*Humerus*	*Antibrachium*	*Metacarpus*	Whole anter. extremity	*Os innominatum*	*Femur*	Crural bones	*Metatarsus*	Whole poster. extremity	Whole periph. skeleton	Whole skeleton	Live weight
14	15	16	17	18	19	20	21	22	23	24	25	26
Newborn (*n*) and Adult (*a*)												
4.36	12.24	11.36	8.57	36.53	7.56	16.21	15.47	9.11	48.35	169.76	335.09	(2300)
19.2	36.6	35.7	24.5	116	16.5	49.6	45.8	23.3	135.2	502.4	1098	6565
8	18	18	12	56	10	22	22	12	66	244	517	2650
57.16	87.05	64.27	31.01	239.49	79.90	107.46	93.18	34.58	315.12	1169.22	2677.16	(42068)
156	163	129	68	511	200	197	166	65	628	2278	5723	92636
138	144	111	55	448	152	168	144	53	517	1930	5043	58900
of Postembryonic Growth by Weight												
1.64	0.89	0.71	0.45	0.82	1.32	0.83	0.75	0.48	0.82	0.82	1.00	—
1.56	0.85	0.69	0.49	0.85	2.33	0.76	0.69	0.54	0.89	0.87	1.00	2.71
1.77	0.82	0.63	0.47	0 82	1.56	0.77	0.67	0.45	0.80	0.81	1.00	2.28
1.38	0.93	0.69	0.50	0.83	1.53	0.94	0.82	0.56	0.92	0.88	1.00	—
1.76	0.82	0.65	0.47	0.82	1.81	0.81	0.68	0.49	0.86	0.84	1.00	3.16
from the Two Other Animals for the Cases: *Aa* : *Cn*, *Ba* : *Cn*, *Ca* : *Cn*												
−0.38	+0.11	+0.04	+0.03	+0.01	−0.28	+0.13	−0.14	+0.07	+0.16	+0.04	0.00	–
−0.39	+0.11	+0.06	+0.03	+0.01	−0.03	+0.17	+0.15	+0.11	+0.12	+0.07	0.00	—

(No. IV and VIII); *C*, the author's own data; *n*, newborn, *a*, adult.
weigh those bones, nor have they been tabulated by the rest of writers. For our animals (*Cn* and *Ca*) *tarsus*, 11 and 48; *phalanges extr. anter.*, 12 and 98; *phal. extr. post.*, 10 and 81; *patella*, 2 and 13.
ted from Chirvinsky as a mean with $n=17$.
of *as innominatum* (Chirvinsky) and of *pelvis* (Hammond) both these writers understand the pelvic belt, reduced to their half.
introduced, the conclusions remain the same.

2) The centres of all gradients are depressed (lumbar region with sacrum).

3) The growth of all the remaining parts is, on the contrary, increased, not without a disturbance of the gradient, *i. e.* with a greater increase of the higher intensities.

Proceeding from the conventionally correct graphical representation of the gradient, such a variation is usually called its «slope» [*c. f.*, for example, (4)].

Thus, the intraspecific peculiarities of the skeletal growth of sheep *Aa* consist in the leveling of intensity differences, in a de-differentiation of all the intensities that make up its system.

It stands to reason that for the other two sheep the formula will be a directly reverse one: increased intensity differences, differentiation of the system, its recession from the type characterized by equal intensities of the two fundamental natural parts of the skeleton.

III. Such a general conclusion seems to be rather promising when applied to development experimentally affected, especially as a premise for an analysis of the interspecific distinctions of intensity systems referring to the same type. It is the more interesting to clear to what extent it holds true, if we renounce to the fiction of an identical original form.

The initial data lacking accuracy, several methods may be applied. I shall

describe here but one of them, the simplest of all, though a sufficiently convincing at the same time. It is the method of comparison of the relative weights of the three newborn.

As shown by calculation, in *An* the axial skeleton is the smallest out of the three (49.34 per cent as compared to 52 per cent in the two other). The difference between the ratios is also the least (1.32, as compared with 9.08 and 5.60 with a reverse sign in the remaining two). The skull is very large (25.33 per cent), as compared to a very small spine column (16.82 per cent). In the other the ratio is 23.43 to 17.25; 20.31 to 21.66, respectively. Inaccurate as they may be, these figures reveal an outspoken tendency, *viz*. the newborn *An* is endowed with the same peculiarities as the adult *Aa*.

Consequently, the conclusion arrived at is significant, though in the course of the real postembryonic growth of the sheep *Aa* the variations found in the intensity system are obscured, having taken place as early as during the embryogenesis.

IV. In order to satisfy the genuine requirements of the theory of growth, quantitative analysis should bring to light new qualitative peculiarities of development, as well. When taking the first steps it is, however, permissible to content oneself with establishing correlations with some peculiarities already known.

In our case it seems natural to correlate the quantitative peculiarities of growth of the sheep *Aa* (Chirvinsky) with the fact that it is the only one out of the three which belongs to the *Ovis aries*, var. *brachyura*, originating from the mouflon-like sheep. According to data by Hammond concerning the height of the parts of skeleton of a half-wild sheep male of the breed Soay, closely approaching the mouflons whose live weight was seven times beyond that of the Suffolks, the same tendencies are still more obvious here. The two remaining sheep, that described by Hammond (a Suffolk) and that investigated by me (Romny-marsh) refer to another extreme variety, *O. ar.* var. *dolichura*, which seems to originate from the arkhar-like sheep [see the classification of Pallas-Natusius-Chirvinsky in modern textbooks on sheep-breeding, as well as (1)].

It is noteworthy that on the ground of linear characters animal-breeding has of late reached conclusions similar to ours. High legs, a large head, a flat chest and a short back, these are characters common of all primitive breeds, which distinguish them from the cultivated ones. The same characters are typical of the young.

In animal-breeding the belief has firmly been established that experimental suppression of the postembryonic development results by the end of growth in similar changes. On the ground of this statement, this science arrives at the generalization known by the name of the «fundamental law of underdevelopment» (Maligonov, 1925). The data obtained by the present author permit to revise the significance of these principles of zootechnics in a new light.

K. A. Timiriazev Agricultural Academy.

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